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Evaluation of Electrical Energy Consumption and Reduction Potential at the 7th Army Training Command (ATC), U.S. Army, Europe

by
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The 7th Army Training Command (ATC), U.S. Army, Europe, has accrued increasingly higher electrical utility bills over the past few years. As is true at most installations, the 7th ATC buildings are not equipped with electricity meters so it is difficult to identify the major power consumers. To determine electrical energy use patterns and potentially find energy conservation opportunities (ECOs), the 7th ATC asked the U.S. Army Construction Engineering Research Laboratory (USACERL) to study electricity consumption at two of its communities, Grafenwöhr and Hohenfels, Federal Republic of Germany.

Results of the predictive modeling and field testing showed several possible ECOs at Grafenwöhr and Hohenfels, such as dimming exterior lights during some hours of the night, providing better controls on oversized ventilation systems in gymnasiums, and training dining hall personnel in energy-conservative practices. A major electrical power consumer is the training ranges; however, since the training mission has priority over energy use, little can be done at this time to reduce consumption there. In the future, target ranges may become available that provide the same quality of training with a lower energy demand.

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FOREWORD

This work was performed for the U.S. Army, Europe (USAREUR) under Military Interdepartmental Purchase Request (MIPR) FE005-88, "Electrical Energy Consumption," dated December 1989. The USAREUR Technical Monitors were Albert R. Duncan and Freddie Rush.

The research was conducted by the U.S. Army Construction Engineering Research Laboratory (USACERL) Energy Systems Division (ES). The work reported in Chapter 8 was completed by the Institute of Gas Technology (IGT) under contract with USACERL. Appreciation is expressed to Larry M. Windingland, principal investigator in FY86, and Lawrence J. Augustine, associate investigator during FY87 and FY88, both of USACERL-ES. Gratitude is expressed to Andrea Stevanovich and Hannon Maase, also of USACERL-ES, for research assistance. The authors also thank personnel at Hohenfels and Grafenwöhr, Federal Republic of Germany, especially Sara Owens, former Hohenfels Energy Coordinator, Roland Repper, Grafenwöhr Energy Coordinator, Angie Graf, 7th Army Training Command Energy Coordinator, Josef Koller, Hohenfels Chief of Utilities, and Werner Ohla, Grafenwöhr Chief of Utilities.

Dr. Gilbert R. Williamson is Chief of ES. LTC E. J. Grabert, Jr. is Commander and Dr. L. R. Shaffer is Director.

CONTENTS

CONTENTS (Cont'd)

FIGURES

FIGURES (Cont'd)

FIGURES (Cont'd)

FIGURES (Cont'd)

TABLES

TABLES (Cont'd)

TABLES (Cont'd)

TABLES (Cont'd)

EVALUATION OF ELECTRICAL ENERGY CONSUMPTION AND REDUCTION POTENTIAL AT THE 7TH ARMY TRAINING COMMAND (ATC), U.S. ARMY, EUROPE

1 INTRODUCTION

Background

The U.S. Army, Europe (USAREUR) consists of several Army commands including the 7th Army Training Command (ATC) located in southeast West Germany. The 7th ATC headquarters at Grafenwöhr oversees communities and subcommunities at Grafenwöhr, Hohenfels, Vilseck, Amberg, and Bindlach.

Consistent with past Army construction practices, most 7th ATC buildings were not equipped with electrical meters. Thus, consumption information on individual buildings was very limited. In 1985, the 7th ATC, prompted by rising electricity bills, became concerned over the lack of available consumption information. Figure 1 shows electrical consumption at 7th ATC for 1977-84. Specific concerns were:

1. What amount of consumption is mission function vs. community support?

2. What portion of consumption is continuous baseline vs. occupant daily operations?

3. What is a reasonable consumption level?

4. What can be done to reduce consumption?

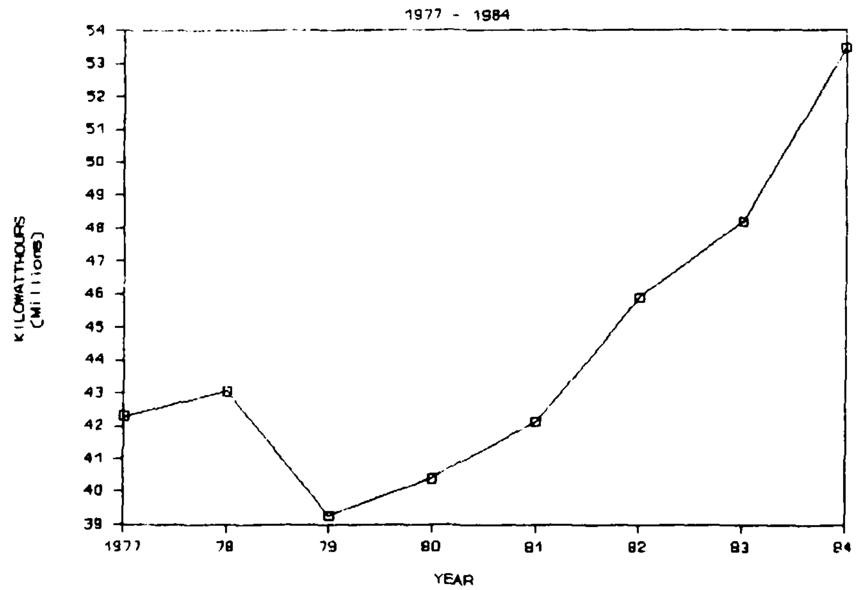

Figure 1. 7th ATC annual electricity use.

As a result of these concerns, USAREUR contacted the U.S. Army Construction Engineering Research Laboratory (USACERL) to evaluate electrical consumption and reduction potential at the 7th ATC.

Objective

The objective of this project was to evaluate electrical energy usage at the 7th ATC and identify potential areas for reducing consumption. This analysis was performed such that the end product is more than just a one-time study for the 7th ATC; the project should result in tools that can continue to be used for electrical energy management by the 7th ATC and other USAREUR communities.

Approach

USACERL's approach was to evaluate current consumption patterns and applicable techniques for reducing electrical use in selected technology areas. It would have been desirable to evaluate consumption first, then select the technology areas to evaluate based on consumption trends. However, time constraints required simultaneous efforts in evaluating both consumption and technologies for reducing it. Therefore, motor and lighting applications were selected (based on expectations that they are major consumers) as two specific technology areas to be evaluated.

The step-by-step evaluation procedure for energy consumption is as follows:

1. Use available building inventory lists for 7th ATC communities to group buildings by function based on the assigned five-digit Army category code.

2. Assist in selecting buildings where metering is to be installed at Grafenwöhr and Hohenfels.

3. Use meter data to establish expected electrical consumption patterns (profiles) for each group/type of buildings.

4. Audit selected buildings to determine electrical loads.

5. Use audit information to subdivide building consumption (profiles) into subgroups (subprofiles): lighting, motors, mission-related loads (e.g., personal computers [PCs], copy machines), and support equipment (e.g., coffee pots, vending machines).

6. Develop audit and meter information into a data base to be used in projecting electrical consumption for any given group of buildings (with category codes and building area) by using the developed profile/subprofiles for each building type.

7. Check the results of using the data base to allow consumption projections at other communities.

8. Develop algorithms for detecting consumption problems in each building's monthly meter readings.

9. Develop a PC-based computer program to automate the previously developed procedures for projecting electrical consumption and detecting meter data problems.

10. Use the above tools to analyze electrical consumption at Hohenfels and Grafenwöhr.

Steps in the concurrent technology evaluation include:

11. Assess current use of electric motors at Grafenwöhr and Hohenfels; evaluate applications for reduced electrical consumption.

12. Assess current use of lighting systems at Grafenwöhr and Hohenfels; evaluate applications for reduced electrical consumption.

13. Evaluate and/or document electrical energy conservation opportunities as determined during consumption analysis and technology assessments.

Scope

This report describes electrical consumption trends and identifies major electrical energy conservation target areas for several U.S. Army installations in West Germany. Due to the mild summer climate in West Germany, many buildings at these Army installations contain no air-conditioning, which can greatly affect electrical usage. Therefore, the trends and conservation areas identified in this report might not apply to Army installations with a different climate.

Report Organization

Chapter 2 describes the activities in establishing a data base of typical building electrical consumption for various building types (**Approach** Steps 1 through 5) at Hohenfels and Grafenwöhr. Chapter 3 discusses algorithms used to detect alarming trends (e.g., growth or extreme variation) in the monthly electrical consumption calculated from meter readings. Chapter 4 describes the PC program to project electrical consumption based on the user's list of buildings and detect monthly consumption trends. Chapters 5 and 6 contain results from evaluations of electrical consumption at Hohenfels and Grafenwöhr, respectively, based chiefly on output information similar to the output of the PC program described in Chapter 4. Chapters 7 and 8 evaluate applications of lighting and motors, respectively, at Hohenfels and Grafenwöhr. Chapter 9 describes other miscellaneous electrical energy conservation opportunities and problems. Chapter 10 presents conclusions and recommendations.

2 ESTABLISHING "TYPICAL" BUILDING CONSUMPTION

Building Categories

Army Regulation (AR) 415-28 provides a list of five-digit category codes for all types of Army buildings and facilities.[1] In the Directorate of Engineering and Housing (DEH) Real Property building list kept at each community, each building is assigned a five-digit code to match its functional use.

Appendix A lists the five-digit codes needed to categorize all of the buildings at Hohenfels and Grafenwöhr. Based on knowledge of building functions and their expected electrical usage, buildings of various category codes that were predicted to have similar consumption were grouped into more general building categories. Category codes of facilities estimated to have no electrical usage (e.g., sediment ponds) were not assigned a building category. Category codes of facilities for which electrical use is not clearly related to building area (e.g., street lighting systems) were assigned to higher numbered (bottom of the list) building categories. Although the method used to arrive at the initial list of building categories was rather subjective, it was regarded as acceptable because, in the end, the meter data would indicate which buildings should or should not be grouped into the same building category. The refined list of building categories is shown in Table 1. Appendix A also indicates the match between category codes and the assigned general building categories.

Meter Selection and Installation

In fiscal year (FY) 1986, USAREUR funded Hohenfels to install kilowatt-hour meters on buildings. USACERL reviewed the buildings selected for metering by the Hohenfels DEH. Installation of permanent kilowatt-hour meters was complete on some 128 buildings and 21 transformer stations at Hohenfels in June 1987. Hohenfels personnel began collecting meter data in March 1987 and continued through April 1989. (Not all meters were read every month.) Meters at Hohenfels are the standard kilowatt-hour type which require manual reading.

To obtain more detailed (hourly) meter information on the Hohenfels' buildings, temporary metering equipment capable of recording hourly electrical usage was provided to the DEH. Two types were installed. Sangamo Data Star Recorders were used to record pulse outputs from the standard kilowatt-hour meters at selected buildings. Readings were retrieved electronically using a hand-held unit, then were downloaded to a PC. Also, Amprobe kilowatt-hour units were provided as clamp-on meters at locations without standard kilowatt-hour meters. These units use paper chart recorders that are relatively inexpensive but that make analysis considerably more difficult.

In FY87, USAREUR funded Grafenwöhr to install kilowatt-hour meters. USACERL worked with Grafenwöhr personnel in selecting meter locations to ensure that meter data could be obtained for buildings representing most categories. Meter installation was nearly complete as of August 1988. About 72 meters were connected to the existing energy monitoring and control system (EMCS). Grafenwöhr personnel downloaded the EMCS data to a PC for USACERL's analysis. The first meter readings recorded and saved at Grafenwöhr were on 8 December 1988 and continued through 20 January 1989.

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[1]Army Regulation (AR) 415-28, *Department of the Army Facility Classes and Construction Categories (Category Codes)* (Headquarters, Department of the Army, 1 November 1981).

Table 1

Defined Building Categories

Building Category Number (Assigned)	Building Category Description	Building Category Number (Assigned)	Building Category Description
0	NO ELECTRICAL USAGE	27	Bowling Center
1	Administration	28	Lunch Room
2	Training	29	Child Support Service Ctr
3	Motor/Tank Maint/Repair Shop	30	Exchange Retail/Sales
4	Storage	31	Exchange Branch
5	Medical	32	Arts/Crafts/Skill Dev Ctr
6	Family Housing	33	Club/Youth/Scout Bldg
7	Troop Housing	34	Community Center
8	Dining/Cafeteria/Snack Bar	35	Gymnasium/Rec Bldg
9	Commissary	36	Library
10	Cold Storage	37	Rec Center/EM Club
11	Heating Plant - Coal/Oil Fired	38	Theater
12	Hutments	39	Class VI Store
13	Training Simulator	40	Misc Sheds/Garages/Detached Bldgs
14	Missile Equip Maint Shop	41	Post Office
15	Electronics/Electr Maint Shop	42	Sentry Station
16	Dining (Troops)	43	Detached Lavatory
17	School	44	Wash Facility
18	Telephone Exchange	45	Rock Crusher Plant
19	Fire Station	46	Transmitter Bldg (Radio)
20	Service Station	47	Installation Water Supply
21	Training Aids Center	48	Exterior Street Lighting
22	POL Pump Station	49	Airfield Area
23	Fac Engr Maint Shop	50	Training Ranges
24	Chapel	51	Sewage Treatment Plant
25	Laundry	99	UNKNOWN ELECTRIC USE
26	Bank		

Building Electrical Audits

Building audit information was collected for subdividing the building total use (profiles) in each building category into more detailed subprofiles. Also, when building meter data were monthly readings (no hourly profile), audit information was used to help construct an estimated profile.

Building electrical audits were performed on a total of 104 buildings at Hohenfels and Grafenwöhr. Appendix B lists the audited buildings. Audits consisted of identifying each electrical load in the building. For unique or unusual types of equipment, an attempt was made to record nameplate kilowatt ratings. For common equipment, kilowatt ratings were established from typical ratings of similar products found in the field, product literature, or nameplate ratings from local equipment.

Establishing Consumption From Meter Data

Meter data from Grafenwöhr and Hohenfels were used to calculate an average consumption in kWh/sq ft/day* from the initial meter reading date to the latest available reading date. Table 2 shows each building's average consumption (with buildings grouped by category) along with the total number of days and frequency of meter readings.

To arrive at a single average kilowatt-hour per square foot per day (KSD) consumption number for each building category, the individual building consumption numbers within each building category were averaged. To reduce the possibility that the building category average would be skewed by individual buildings with small areas (e.g., unusually high consumption density) or by individual buildings metered for a short time (e.g., possibly atypical consumption during meter period), the building category average was computed as a *weighted* average. The weighted average was computed by using "the number of days of meter readings" and "building area (square feet)" as multipliers before averaging. Thus, larger buildings and those metered for longer periods contributed most to the weighted building category average. Table 3 shows the computed weighted average (kWh/sq ft/day), number of metered buildings contributing to the average, and a nonweighted average with the associated standard deviation value for each building category.

Establishing Individual Building Consumption Subprofiles

For each audited building, every electrical load was placed into one of four possible groups: lighting, motors, mission-related loads, and support (nonmission)-related loads. Each load was assigned a use factor for each hour of the day based on estimated consumption in the building. Loads within each of the four groups were summed to provide an hour-by-hour subprofile for lighting, motor mission equipment, and support equipment loads.

*Metric conversion factors are given on p 215.

Table 2

Average Kilowatt-Hours per Day for Metered Buildings

Bldg Cat.	Comm-unity	Bldg No.	Description	Area	kWh/sq ft/ day (KSD)	Days of Metering	Data Collection Frequency
1	Hoh.	98	co hq bldg	3706	0.009191	217	Mnthly
1	Hoh.	745	adm & supply bldg	3328	0.012539	395	Mnthly
1	Hoh.	85	engr admn bldg	3378	0.011163	309	Mnthly
1	Hoh.	744	ls locker area	3328	0.002908	395	Mnthly
1	Hoh.	359	admin gen purp	3328	0.002522	309	Mnthly
1	Graf.	531		20945	0.006882	18	Hrly
1	Hoh.	363	admin gen purp	3328	0.005164	217	Mnthly
1	Hoh.	161	bn hq building	4664	0.006306	276	Mnthly
1	Hoh.	1 A	post hq bldg.	31255	0.005773	395	Mnthly
1	Hoh.	224	bn hq building	3328	0.005552	304	Mnthly
1	Hoh.	366	bn hq shed	4664	0.006755	309	Mnthly
1	Hoh.	254	bn hq building	3328	0.005407	304	Mnthly
1	Hoh.	105	bn hq building	3328	0.002385	304	Mnthly
1	Hoh.	128	rgt/bde hq bldg	3328	0.009737	304	Mnthly
1	Graf.	500		20839	0.012046	18	Hrly
1	Hoh.	9 a	dispatch office	391	0.009193	217	Mnthly
1	Hoh.	189	bn hq building	3328	0.004222	304	Mnthly
1	Graf.	329.2	0.0269830936	12735	0.026983	18	Hrly
1	Graf.	621		37921	0.012786	17	Hrly
2	Graf.	533		20941	0.014050	18	Hrly
2	Hoh.	376	classroom	4664	0.000608	309	Mnthly
2	Hoh.	382	gen instr bldg	3661	0.005266	217	Mnthly
2	Hoh.	42	aces facility	6413	0.013068	487	Mnthly
2	Hoh.	383	gen instr bldg	3661	0.003668	217	Mnthly
2	Hoh.	327	gen instr bldg	4664	0.005917	280	Mnthly
2	Hoh.	384	gen instr bldg	3328	0.004484	184	Mnthly
2	Hoh.	386	gen instr bldg	3328	0.004502	366	Mnthly
2	Hoh.	351	gen instr bldg	4664	0.004375	309	Mnthly
2	Hoh.	270	gen instr bldg	4664	0.015285	487	Mnthly
2	hoh.	385	gen instr bldg	3328	0.004063	184	Mnthly
3	Hoh.	392 X	veh mnt dir sup	17834	0.017799	151	Mnthly
3	Hoh.	271	veh mnt shop	17735	0.002202	244	Mnthly
3	Hoh.	390	veh mnt dir sup	4684	0.016086	487	Mnthly
3	Graf.	602		11984	0.019476	18	Hrly
3	Hoh.	9	veh mnt shop	9047	0.005784	309	Mnthly
4	Hoh.	122	gen storehouse	3328	0.006907	487	Mnthly
4	Graf.	308		9018	0.007055	18	Hrly
4	Hoh.	170	gen storehouse	3328	0.002389	487	Mnthly

Table 2 (Cont'd)

Bldg Cat.	Community	Bldg No.	Description	Area	kWh/sq ft/ day (KSD)	Days of Metering	Data Collection Frequency
4	Hoh.	12	gen purp wareho	14826	0.005632	487	Mnthly
4	Hoh.	70	commissary ware	6110	0.01999	487	Mnthly
4	Hoh.	388	storage room	6110	0.005099	487	Mnthly
4	Hoh.	31	fe storehouse	6647	0.012181	395	Mnthly
5	Hoh.	51	clinic w/beds	22203	0.010008	487	Mnthly
6	Hoh.	74	family housing	25040	0.010507	29	Mnthly
6	Hoh.	73	family housing	23088	0.008692	29	Mnthly
6	Hoh.	75	family housing	21216	0.013286	29	Mnthly
7	Graf.	212		8855	0.013130	18	Hrly
7	Hoh.	380	enl bks w/o din	3328	0.011884	280	Mnthly
7	Hoh.	373	enl bks w/o din	3328	0.015871	217	Mnthly
7	Hoh.	747	civilian dorm	6110	0.002168	184	Mnthly
7	Graf.	634		38215	0.011655	18	Hrly
7	Hoh.	16	enl barracks w/	7005	0.011266	217	Mnthly
7	Graf.	632		38297	0.011945	18	Hrly
7	Hoh.	17	enl barracks w/	7005	0.018574	395	Mnthly
7	Hoh.	365	enl bks w/o din	3328	0.012880	217	Mnthly
7	Hoh.	20	sen enl pers qu	7005	0.017588	395	Mnthly
7	Hoh.	22	enl barracks w/	7005	0.017306	217	Mnthly
7	Hoh.	21	enl barracks w/	7005	0.015812	217	Mnthly
7	Hoh.	349	enl bks w/o din	3328	0.016731	309	Mnthly
7	Hoh.	364	enl bks w/o din	3328	0.013133	151	Mnthly
7	Hoh.	372	enl bks w/o din	3328	0.021640	309	Mnthly
7	Hoh.	309	civilian dorm	9381	0.005889	309	Mnthly
8	Graf.	207		1248	0.099039	18	Hrly
8	Graf.	622		13710	0.070942	17	Hrly
8	Hoh.	3 B	cafe, cooling unit	5076	0.138390	395	Mnthly
9	Hoh.	1 b	commissary	7066	0.101721	29	Mnthly
9	Graf.	150	commissary	11668	0.151169	43	hrly
10	Hoh.	10	cold storage	24790	0.017600	71	Hrly
11	Hoh.	274 a	sub, Ht plant	6892	0.112345	392	Mnthly
11	Graf.	210		462	0.646625	17	Hrly
11	Hoh.	320 a	substation, HT	6700	0.118557	272	Mnthly
11	Graf.	285		4238	0.141498	18	Hrly
11	Hoh.	3 A	heating pl coal	2893	0.223319	395	Mnthly
12	Hoh.	336	hutments	3328	0.001944	217	Mnthly
12	Hoh.	102	hutments	3328	0.000527	304	Mnthly
12	Hoh.	108	hutments	3328	0.000954	304	Mnthly
12	Hoh.	248	hutments	3328	0.003012	304	Mnthly
12	Hoh.	110	hutments	3328	0.001623	304	Mnthly
12	Hoh.	242	hutments	3328	0.003290	276	Mnthly

Table 2 (Cont'd)

Bldg Cat.	Comm-unity	Bldg No.	Description	Area	kWh/sq ft/ day (KSD)	Days of Metering	Data Collection Frequency
12	Hoh.	111	hutments	3328	0.002105	304	Mnthly
12	Hoh.	239	hutments	3328	0.002572	304	Mnthly
12	Hoh.	114	hutments	3328	0.000535	276	Mnthly
12	Hoh.	236	hutments	3328	0.001995	304	Mnthly
12	Hoh.	116	hutments	3328	0.004342	304	Mnthly
12	Hoh.	321	hutments	3328	0.002329	217	Mnthly
12	Hoh.	120	hutments	3328	0.000934	304	Mnthly
12	Hoh.	323	hutments	3328	0.003555	395	Mnthly
12	Hoh.	125	hutments	3328	0.001126	304	Mnthly
12	Hoh.	325	hutments	3328	0.001646	184	Mnthly
12	Hoh.	129	hutments	3328	0.000808	304	Mnthly
12	Hoh.	326	hutments	3328	0.002055	395	Mnthly
12	Hoh.	131	hutments	3328	0.001113	304	Mnthly
12	Hoh.	223	hutments	3328	0.004917	304	Mnthly
12	Hoh.	135	hutments	3328	0.001497	304	Mnthly
12	Hoh.	220	hutments	3328	0.002078	304	Mnthly
12	Hoh.	137	hutments	3328	0.001154	304	Mnthly
12	Hoh.	214	hutments	3328	0.003073	304	Mnthly
12	Hoh.	140	hutments	3328	0.002252	304	Mnthly
12	Hoh.	357	hutments	3328	0.002769	309	Mnthly
12	Hoh.	143	hutments	3328	0.002019	304	Mnthly
12	Graf.	1180		26352	0.004207	18	Hrly
12	Hoh.	144	hutments	3328	0.007063	243	Mnthly
12	Hoh.	381	hutments	3328	0.003636	217	Mnthly
12	Graf.	2200		26352	0.007167	18	Hrly
12	Hoh.	213	hutments	3328	0.001899	304	Mnthly
12	Hoh.	207	hutments	3328	0.001356	304	Mnthly
12	Hoh.	244	hutments	3328	0.001675	304	Mnthly
12	Hoh.	147	hutments	3328	0.001662	304	Mnthly
12	Hoh.	253	hutments	3328	0.002438	304	Mnthly
12	Hoh.	149	hutments	3328	0.002645	304	Mnthly
12	Hoh.	234	hutments	3328	0.001785	304	Mnthly
12	Hoh.	172	hutments	3328	0.006840	304	Mnthly
12	Hoh.	230	hutments	3328	0.001012	304	Mnthly
12	Hoh.	173	hutments	3328	0.007712	304	Mnthly
12	Hoh.	334	hutments	3328	0.001636	217	Mnthly
12	Hoh.	175	hutments	3328	0.010182	304	Mnthly
12	Hoh.	218	hutments	3328	0.004344	304	Mnthly
12	Hoh.	176	hutments	3328	0.008892	304	Mnthly
12	Hoh.	204	hutments	3328	0.003211	304	Mnthly
12	Hoh.	178	hutments	3328	0.000302	244	Mnthly

Table 2 (Cont'd)

Bldg Cat.	Comm-unity	Bldg No.	Description	Area	kWh/sq ft/day (KSD)	Days of Metering	Data Collection Frequency
12	Hoh.	250	hutments	3328	0.002908	304	Mnthly
12	Hoh.	193	hutments	3328	0.003141	276	Mnthly
12	Hoh.	233	hutments	3328	0.002028	304	Mnthly
12	Hoh.	195	hutments	3328	0.001246	304	Mnthly
12	Hoh.	335	hutments	3328	0.001357	217	Mnthly
12	Hoh.	197	hutments	3328	0.001491	304	Mnthly
12	Hoh.	210	hutments	3328	0.001725	304	Mnthly
12	Hoh.	201	hutments	3328	0.001206	304	Mnthly
12	Hoh.	228	hutments	3328	0.002072	304	Mnthly
12	Hoh.	258	hutments	3328	0.001487	304	Mnthly
12	Hoh.	356	hutments	3328	0.001066	217	Mnthly
12	Hoh.	203	hutments	3328	0.001565	304	Mnthly
13	Graf.	2008		6588	0.029199	18	Hrly
14	Graf.	651		7763	0.014482	18	Hrly
14	Graf.	655		1490	0.038696	18	Hrly
15	Hoh.	511	elec mnt shop	16076	0.021090	331	Mnthly
16	Hoh.	358	enl pers dining	5404	0.017321	309	Mnthly
16	Hoh.	165	enl pers dining	4664	0.025760	304	Mnthly
16	Hoh.	164	enl pers dining	4664	0.024130	276	Mnthly
16	Hoh.	269	enl pers dining	4664	0.023156	304	Mnthly
16	Hoh.	163	enl pers dining	4664	0.032147	276	Mnthly
16	Hoh.	267	enl pers dining	4664	0.022112	304	Mnthly
16	Hoh.	162	enl pers dining	4664	0.035737	304	Mnthly
16	Hoh.	264	enl pers dining	4664	0.024952	304	Mnthly
16	Hoh.	159	enl pers dining	4664	0.023424	304	Mnthly
16	Hoh.	262	enl pers dining	4664	0.029683	304	Mnthly
16	Hoh.	158	enl pers dining	4664	0.010748	304	Mnthly
16	Hoh.	260	enl pers dining	4664	0.035148	304	Mnthly
16	Hoh.	157	enl pers dining	4664	0.019599	304	Mnthly
16	Hoh.	186	enl pers dining	4664	0.033246	304	Mnthly
16	Hoh.	156	enl pers dining	4664	0.021014	304	Mnthly
16	Hoh.	184	enl pers dining	4664	0.031829	304	Mnthly
16	Hoh.	155	enl pers dining	4664	0.021355	304	Mnthly
16	Hoh.	182	enl pers dining	4664	0.030847	304	Mnthly
16	Hoh.	154	enl pers dining	4664	0.019717	304	Mnthly
16	Hoh.	24	enl pers dining	2166	0.019401	395	Mnthly
16	Hoh.	43	dining facility	6897	0.039900	309	Mnthly
16	Hoh.	166	enl pers dining	4664	0.026080	304	Mnthly
16	Graf.	101		9810	0.139965	18	Hrly
16	Hoh.	268	enl pers dining	4664	0.004538	304	Mnthly
16	Graf.	445		14223	0.051748	18	Hrly

Table 2 (Cont'd)

Bldg Cat.	Community	Bldg No.	Description	Area	kWh/sq ft/ day (KSD)	Days of Metering	Data Collection Frequency
16	Hoh.	263	enl pers dining	4664	0.022070	304	Mnthly
16	Hoh.	167	enl pers dining	4664	0.026780	304	Mnthly
16	Hoh.	261	enl pers dining	4664	0.028033	304	Mnthly
16	Hoh.	259	enl pers dining	4664	0.028371	304	Mnthly
16	Hoh.	183	enl pers dining	4664	0.020221	304	Mnthly
16	Hoh.	185	enl pers dining	4664	0.032161	304	Mnthly
16	Hoh.	181	enl pers dining	4664	0.016000	304	Mnthly
16	Hoh.	265	enl pers dining	4664	0.036604	304	Mnthly
17	Hoh.	5	dep grade school	15500	0.006118	395	Mnthly
17	Graf.	122		4169	0.009516	18	Hrly
18	Hoh.	54	tel exch build	4500	0.059827	487	Mnthly
19	Graf.	521		8369	0.011699	18	Hrly
19	Hoh.	48	fire station	3929	0.030149	272	Mnthly
21	Graf.	1030		10310	0.002317	18	Hrly
23	Graf.	329.1		35155	0.013355	18	Hrly
23	Graf.	310		5171	0.005783	18	Hrly
24	Hoh.	2	post chapel	4420	0.007282	395	Mnthly
24	Hoh.	179	unit chapel	3328	0.002670	304	Mnthly
25	Graf.	2443		3294	0.041857	18	Hrly
25	Graf.	2442		3294	0.080718	18	Hrly
25	Hoh.	72 A	laundry (est sq)	3000	0.058724	29	Mnthly
26	Graf.	105		7649	0.003468	17	Hrly
27	Hoh.	14	bowling center	3877	0.07639	395	Mnthly
28	Hoh.	180	Bundeswehr Cant	4664	0.010165	276	Mnthly
28	Hoh.	315	Labor Service Ctr	4664	0.024234	309	Mnthly
29	Hoh.	94	child sup svc ctr	1375	0.019130	395	Mnthly
29	Hoh.	95	child sup svc ctr	1625	0.018623	395	Mnthly
30	Hoh.	3 D	exch main ret	11097	0.007209	395	Mnthly
30	Hoh.	169	clothg sales st	3328	0.013906	487	Mnthly
30	Hoh.	160	exch serv outlet	4664	0.074677	487	Mnthly
30	Graf.	141		13133	0.038198	18	Hrly
30	Graf.	1008		3854	0.029560	18	Hrly
31	Hoh.	h-15 a	AAFES audio vis	3436	0.020274	458	Mnthly
31	Graf.	148		1073	0.044789	18	Hrly
32	Hoh.	746	entertainment	6175	0.001007	395	Mnthly
32	Hoh.	18	arts/crafts/ski	5552	0.011738	29	Mnthly
33	Hoh.	83	welcome center	3978	0.012002	487	Mnthly
33	Graf.	508		8274	0.010924	18	Hrly
33	Hoh.	50	youth center	4664	0.006509	458	Mnthly
34	Hoh.	703	community center	3795	0.007176	395	Mnthly
35	Graf.	547		36984	0.057854	18	Hrly

Table 2 (Cont'd)

Bldg Cat.	Comm-unity	Bldg No.	Description	Area	kWh/sq ft/day (KSD)	Days of Metering	Data Collection Frequency
35	Hoh.	88	gymnasium	22200	0.039381	395	Mnthly
36	Graf.	107		5348	0.012895	12	Hrly
36	Hoh.	49	library main	3328	0.009864	395	Mnthly
37	Hoh.	40	recreation cent	18386	0.012217	87	Mnthly
38	Graf.	2060		11101	0.013418	18	Hrly
39	Hoh.	63	class VI store	1780	0.043080	366	Mnthly
39	Graf.	141 A		3018	0.029714	18	Hrly
43	Graf.	2225		2000	0.037886	17	Hrly
44	Hoh.	277	XFMR Station, recyle wash	no area		366	Mnthly
45	Hoh.	297 a	XFMR Station, Rock Crusher	no area		392	Mnthly
46	Graf.	259		1276	0.056099	14	Hrly
46	Hoh.	387	PX shower room	4664	0.004196	487	Mnthly
46	Hoh.	174	det lavatory bl	2482	0.012876	487	Mnthly
47	Hoh.	h-601	substation, Water	50	34.96897	392	Mnthly
49	Hoh.	701	sub, Airfield	no area		392	Mnthly
49	Hoh.	739	weather station	641	0.029431	395	Mnthly
51	Hoh.	719 a	sub, Sewage Plant	no area		392	Mnthly
52	Hoh.	659	sub, tactical site	no area		29	Mnthly
52	Hoh.	979	sub, tactical site	no area		29	Mnthly

Table 3

Average Kilowatt-Hours per Day for Building Categories

Building Category No.	Description	Weighted Avg. kWh/sq ft/day	No. of Metered Bldgs.	Avg.	Std. Dev.
1	Administration	0.006582	19	0.008291	0.005466
2	Training	0.008116	11	0.006845	0.004662
3	Motor/Tank Maint/Repair Shop	0.009302	5	0.012270	0.006935
4	Storage	0.008517	7	0.008465	0.005442
5	Medical	0.010009	1	0.010009	
6	Family Housing	0.010753	3	0.010829	0.001889
7	Troop Housing	0.013759	16	0.013592	0.004643
8	Dining/Cafeteria/Snack Bar	0.131045	3	0.102791	0.027663
9	Commissary	0.136830	2	0.126445	0.024724
10	Cold Storage	0.017600	1	0.017600	
11	Heating Plant - Coal/Oil Fired	0.137481	5	0.248469	0.202983
12	Hutments	0.002631	59	0.002665	0.002075
13	Training Simulator	0.029200	1	0.029200	
14	Missile Equip Maint Shop	0.018381	2	0.026589	0.012107
15	Electronics/Electr Maint Shop	0.021090	1	0.021090	
16	Dining (Troops)	0 025539	33	0.029509	0.021363
17	School	0.006160	2	0.007818	0.001699
18	Telephone Exchange	0.059828	1	0.059828	
19	Fire Station	0.027870	2	0.020924	0.009225
20	Service Station	0.061257	0		
21	Training Aids Center	0.002317	1	0.002317	
22	POL Pump Station	0.080976	0		
23	Fac Engr Maint Shop	0.012385	2	0.009570	0.003786
24	Chapel	0.005590	2	0.004976	0.002306
25	Laundry	0.060203	3	0.060433	0.015911
26	Bank	0.003469	1	0.003469	
27	Bowling Center	0.076390	1	0.076390	
28	Lunch Room	0.017597	2	0.017200	0.007034
29	Child Support Service Ctr	0.018856	2	0.018877	0.000253
30	Exchange Retail/Sales	0.027367	5	0.032711	0.023686
31	Exchange Branch	0.020571	2	0.032532	0.012258
32	Arts/Crafts/Skill Dev Ctr	0.001672	2	0.006373	0.005365
33	Club/Youth/Scout Bldg	0.009185	3	0.009812	0.002376
34	Community Center	0.007177	1	0.007177	
35	Gymnasium/Rec Bldg	0.040685	2	0.048618	0.009236
36	Library	0.010006	2	0.011380	0.001515
37	Rec Center/EM Club	0.012218	1	0.012218	
38	Theater	0.013418	1	0.013418	
39	Class VI Store	0.042052	2	0.036397	0.006683
40	Misc Sheds/Garages/Detached Bldg	0.002129	0		
41	Post Office	0.006582	0		
42	Sentry Station	0.069689	0		
43	Detached Lavatory	0.037886	1	0.037886	

Establishing Individual Building Consumption Profiles

The four subprofiles described above were summed to provide an initial estimated consumption profile for each building. Then this initial profile was adjusted higher or lower to match meter information by one of the methods described below, depending on whether the meter data were hourly or monthly readings.For buildings from which meter data were in the form of a profile (hourly data) such as the data received from Grafenwöhr's EMCS connected meters, the hour-by-hour initially estimated profile was adjusted to directly coincide with the actual hourly meter data. This adjustment was made by first computing the difference between the desired hourly total from the meter data and the initial estimated total for each hour. Then this difference was spread proportionately among the individual loads operating during a given hour. Thus, after adjustment, the sum of the estimated loads in any given hour exactly equaled the meter total for the hour.

For buildings with monthly meter data such as most of those at Hohenfels, the initial estimated hourly profile obtained from summing the four subprofiles was used to compute a KSD number by summing the 24 hourly numbers. This computed (from initial estimate) KSD number was compared with the average KSD computed from the meter data. The difference between the two KSD numbers was redistributed proportionately back to each of the 24 hourly totals, thus providing a new "desired" profile that matches the meter data. At this point, having developed a desired hour-by-hour profile, each of the individual hourly loads were adjusted in exactly the same way as described above for buildings from which hourly meter data were available.

Establishing Profile Category Profiles/Subprofiles

The individual building profiles and subprofiles (described above) within each building category were averaged to arrive at an unadjusted average total profile and four subprofiles for each building category. Table 4 lists the individual buildings in each category that were used to arrive at hourly profiles.

In some building categories, individual building profiles/subprofiles were not developed for all metered buildings due to the limited time for performing building audits. For example, in building category 1--administration--only six individual building profiles/subprofiles were developed although meter data were obtained for 19 administration buildings. However, all 19 buildings were used previously to calculate the average (kWh/sq ft/day) consumption. Therefore, the unadjusted profiles/subprofiles obtained by averaging the six individual buildings were adjusted to match the average KSD number calculated from the 19 administration buildings. This adjustment was made by adding or subtracting to each of the 24 hourly numbers (in accordance with each number's relative size) until the sum of all 24 numbers equaled the desired KSD number.

Figure 2 is a flow diagram of the profile development procedure. Each step uses elementary arithmetic only.

Nonstandard Profile Category Development and General Comments

The procedures described above for standardized development of profiles/subprofiles could not be used for building categories where no meter data were available and for those where consumption was not directly related to building area. Below are general comments and descriptions of the methodology associated with some of the nonstandard categories.

Table 4

Buildings Used to Define Each Building Category Profile

Bldg. Cat.	Comm-unity	Bldg. No.	Bldg. Area(sq ft)	Bldg. Cat.	Comm-unity	Bldg. No.	Bldg. Area(sq ft)
1	Hoh.	744	3328	17	Hoh.	122	4169
1	Hoh.	745	3328	17	Hoh.	5	15500
1	Hoh.	37	5298	18	Hoh.	54	4500
1	Hoh.	500	20839	20	Hoh.	441	1224
1	Hoh.	531	20945	21	Hoh.	1030	10310
1	Hoh.	621	37921	22	Graf.	372	350
2	Hoh.	533	20941	22	Graf.	324	424
2	Hoh.	386	3328	22	Graf.	371	137
2	Hoh.	270	4664	22	Graf.	373	194
2	Hoh.	42	6413	23	Hoh.	329	35155
3	Hoh.	602	11984	24	Hoh.	2	4420
3	Hoh.	390	14684	25	Hoh.	2443	3294
3	Hoh.	9	9047	25	Hoh.	2442	3294
4	Graf.	308	9018	26	Hoh.	105	7649
4	Hoh.	12	14826	27	Hoh.	14	3877
5	Hoh.	51	22203	28	ESTIMATE (HALF OF BC 8)		
6	Hoh.	75	21216	29	Hoh.	95	1625
6	Hoh.	74	25040	29	Hoh.	94	1375
6	Hoh.	73	23088	30	Hoh.	169	3328
7	Graf.	634	38215	30	Graf.	1008	3854
7	Hoh.	212	8855	30	Hoh.	3D	11097
7	Hoh.	20	7005	30	Hoh.	141	13133
7	Graf.	632	38297	31	Hoh.	H-15	3436
7	Hoh.	22	7005	31	Hoh.	148	1073
7	Hoh.	21	7005	31	Hoh.	387	4664
7	Hoh.	17	7005	32	Hoh.	18	5552
8	Hoh.	622	13710	33	Hoh.	508	8274
8	Hoh.	207	1248	33	Hoh.	50	4664
9	Hoh.	150	11668	33	Hoh.	83	361
9	Hoh.	1	7066	34	Hoh.	703	3795
10	Hoh.	10	24790	35	Hoh.	547	36984
11	Hoh.	285	4238	35	Hoh.	88	22200
11	Hoh.	320	6700	35	Hoh.	47	10951
11	Hoh.	274	6892	36	Hoh.	107	5348
11	Hoh.	210	462	36	Hoh.	49	3328
11	Hoh.	3A	2893	37	Hoh.	40	18386
12	Hoh.	323	3328	38	Hoh.	2060	11101
12	Hoh.	326	3328	39	Hoh.	141A	3018
12	Hoh.	1180	26352	39	Hoh.	63	1780
12	Hoh.	2200	26352	40	Graf.	521	8369
13	Hoh.	2008	3294	40	ESTIMATE (1/4 of BC 4)		
14	Hoh.	655	1490	41	ESTIMATE (SAME AS BC 1)		
14	Hoh.	651	7763	42	ESTIMATE (winter)		
15	Hoh.	511	16076	43	Hoh.	2225	2000
16	Hoh.	445	14223	43	Hoh.	174	2482
16	Hoh.	24	12166				
16	Hoh.	101	9810				

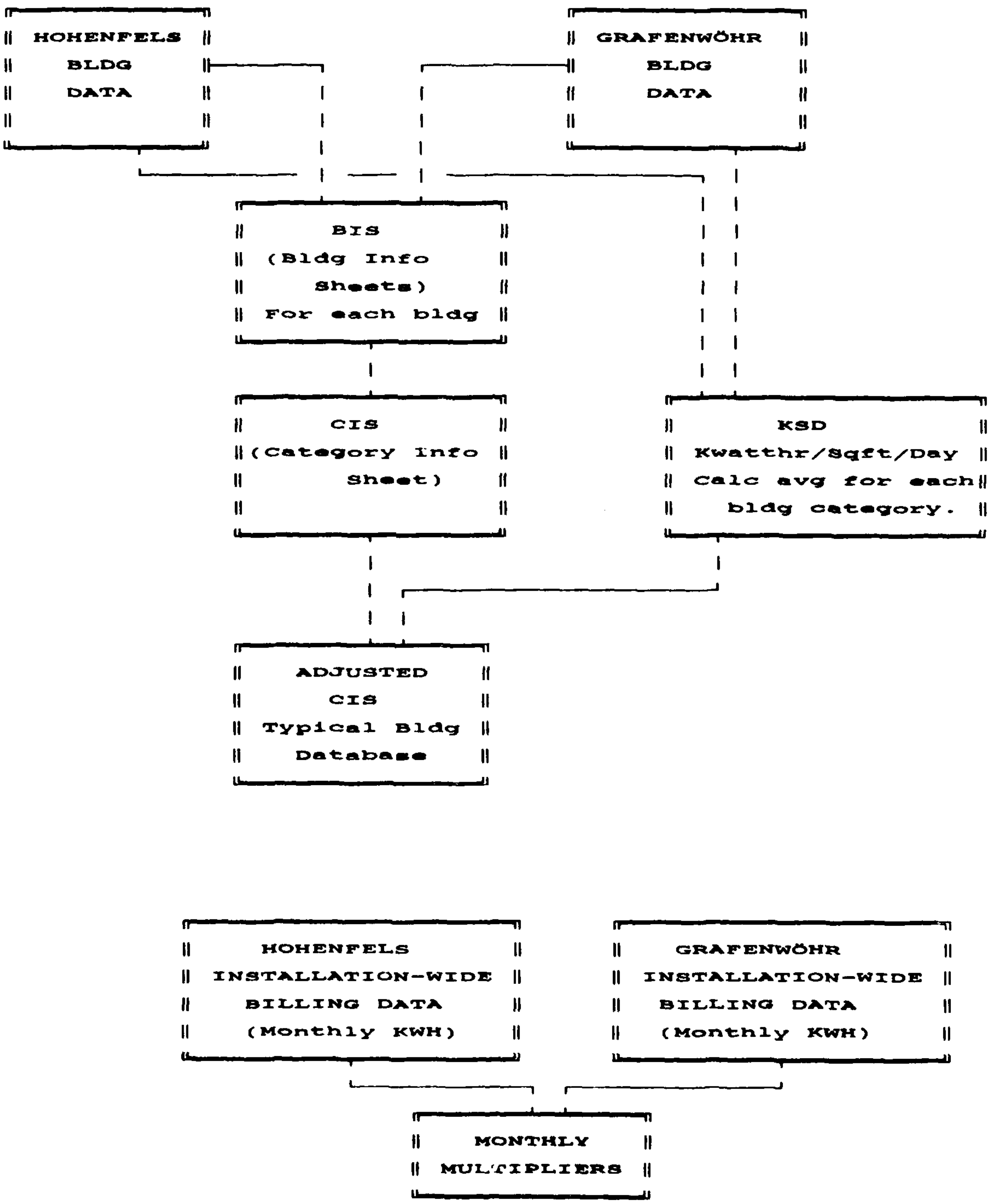


Figure 2. Building data base development.

The electrical consumption of several profile categories was estimated due to meter data being unavailable for a variety of reasons.

Building category 20--"Service Station" was estimated (no meter data). The estimate was based on an audit of Grafenwöhr building 441 (building area = 1242 sq ft) and an initial estimate of usage for the loads. The loads consisted of the following:

	Approx. Watts
Lighting (mostly exterior)	1800
Motors (pumps, air compressor heater)	5900
Mission equip.	25
Support equip.	1200

Building category 22--"POL Pump Station" was estimated (no meter data). The estimate was based on approximations by POL yard personnel concerning the number of operating hours per day for each pump and on the nameplate ratings for the pumps. The four buildings have a combined total area of 1105 sq ft. The electrical load consists of 5 pumps (about 41 kW).

Building category 40--"Miscellaneous Sheds/Garages/Detached Buildings" was estimated (no meter data). It was anticipated that this category would not be of major significance as an electrical load even though the number of buildings was sizable. Building area for 213 Hohenfels and 78 Grafenwöhr buildings is about 81,000 and 107,000 sq ft, respectively. It is a difficult category to estimate. Many of the buildings in this category do not have electrical service. For lack of a better estimate, this category was arbitrarily estimated to consume one-fourth of that for building category 4--"Storage" on an hourly per square foot basis. This assumption resulted in an estimated total electrical consumption of about 3900 kWh/month at Hohenfels and 4900 kWh/month at Grafenwöhr.

Building category 42--"Sentry Station" was estimated (no meter data). The estimate was based on projected usage of the following loads within the assumed "typical" building of 54 sq ft area:

	Approx. Watts
Lighting	112
Support equip. (coffee pot, radio, fan/heater)	869

Several building categories that were not expected to correlate well with individual building areas required special examination in order to develop a profile of electrical usage on a case-by-case basis. Some facilities in these categories could be metered successfully. Others, such as exterior street lighting, were estimated from available information and assumptions about operation.

The building category 44--"Wash Facility" was developed based on meter data from the Hohenfels centralized tank wash facility. Hourly usage was estimated and divided by total pump capacity for the facility, resulting in hourly profile numbers with units of watt-hours per hour per kilowatt of pump capacity. Therefore, to project consumption for this building category, the pump capacity for the facility had to be known (or the default value of 206 kW used) to serve as a multiplier for the profile numbers. This method for projecting consumption has not been tested at other installations and was therefore used with caution.

Building category 45--"Rock Crusher Plant" was developed based on meter data from the Hohenfels facility. The hourly profile numbers developed have units of watt-hours per hour per total installation building square footage. Thus, to project consumption for this type of facility, the profile numbers had to be multiplied by the total building area square feet of the installation where the facility is located. This method for projecting consumption also has not been tested at other installations and was therefore used with caution.

No profile was developed for building category 46--"Transmitter Building (Radio)" due to a lack of meter data.

Building category 47--"Installation Water Supply" was developed based on meter and operating information from Hohenfels and Grafenwöhr. Profile numbers have units of watt-hours per hour per total installation building square footage. Thus, to project installation-wide consumption for these types of facilities, the profile numbers had to be multiplied by the total building area of the installation.

Building category 48--"Exterior Street Lighting" was developed by estimating the number and type of fixtures from the exterior lighting maps available at Hohenfels and Grafenwöhr. Watt ratings for fixtures were assumed to be values commonly found for the application. Hours of operation were computed based on the hours of darkness for the approximate longitude and latitude of Hohenfels and Grafenwöhr. Profile numbers have units of watt-hours per hour per total installation building square footage. Thus, to project installation-wide consumption for these types of facilities, the profile numbers had to be multiplied by the total building area of the installation.

Building category 49--"Airfield Area" was developed using airfield meter data from Hohenfels and Grafenwöhr. Hourly profile numbers have units of watt-hours per hour per square foot of airfield building area. Thus, to project airfield area consumption for the installation, profile numbers must be multiplied by the total area of all buildings that have category codes identifying them as airfield-related facilities.

Building category 50--"Training Ranges" was developed using Grafenwöhr range meter data. Hourly profile numbers have units of watt-hours per hour per kilowatt of target heaters. To project usage for a particular range, the profile numbers must be multiplied by the total kilowatt load of target heater.

Building category 51--"Sewage Treatment Plant" was developed using meter data and information from the Hohenfels plant. Hourly profile numbers have units of watt-hours per hour per total installation building square footage. Thus, to project installation-wide consumption for these types of facilities, the profile numbers must be multiplied by the total building area of the installation.

The profile and subprofile hourly numbers for each building category are listed in Appendix C. These building category data do not indicate a range of accuracy and, as noted previously, many building category numbers are based on minimal information. These numbers are shown to make some building information available when more detailed data are unavailable. The reader should take note of the number of buildings and amount of meter data used to formulate the profile for any particular building category of interest.

Development of Monthly Multipliers for Typical Consumption

The typical building consumption profiles that were developed as described above do not account for possible changes in electrical usage between months or seasons of the year. If monthly or seasonal trends could be detected in meter data, a multiplier could be assigned to adjust the typical consumption

numbers to provide a closer projection of actual consumption. A specific multiplier for each building category would be ideal. However, due to the limited quantity of meter data, USACERL chose to develop a single multiplier for each month which will be used for all building categories.

The monthly multipliers were developed by comparing each month's consumption to the average of 12 months' consumption for the calendar year. Thus, a number slightly greater or less than 1 was obtained for each calendar month. All of the computed January numbers for the years 1981 through 1988 for both Hohenfels and Grafenwöhr were averaged to obtain one number (the multiplier) for January. Likewise, multipliers for the other 11 months were calculated. Figure 3 shows the multipliers developed for each month along with the individual multiplier components for Grafenwöhr and Hohenfels.

Hohenfels' Actual Consumption vs. Projections Using "Typical" Building Data

To examine how well Hohenfels' electrical consumption could be projected using the typical building information derived from buildings at both Hohenfels and Grafenwöhr, actual consumption from utility bills and projected consumption were compared. Actual vs. projected consumption was compared for total installation-wide monthly kilowatt-hour consumption, monthly peak demand, and hour-by-hour demand for two specific time periods.

Total Kilowatt-Hours per Month

Column 4 of Table 5 shows actual kilowatt-hour consumption for 1986 through 1988. Column 7 shows the consumption projected for the same time periods. Column 7 used the projection numbers 30,730 and 25,377 kWh/day for weekdays and weekends, respectively. These weekday and weekend numbers were derived by multiplying the typical building data base numbers (kWh/sq ft/day) by the appropriate area (sq ft) for each building category and then summing. Column 7 was calculated as follows:

$$\text{PROJCONS} = [(30730 \times \text{wkdays}) + (25377 \times \text{wkend})] \times \text{MULTPLR} \qquad \text{[Eq 1]}$$

where: PROJCONS = projected monthly electrical kWh
wkdays = number of weekdays in the month
wkend = number of weekend days in the month
MULTPLR = the monthly multiplier derived previously in this chapter.

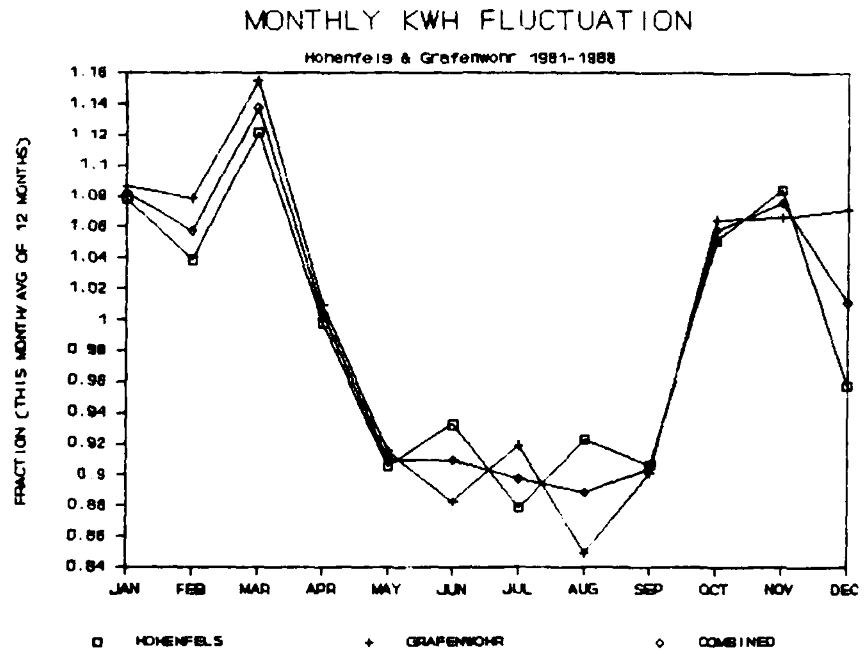
Column 9 is the percent difference between projected and actual. A positive quantity indicates that more electrical usage was projected than actually occurred. Column 9 is shown graphically in Figure 4. Most of the consumption projections compared to actual values are in a range from -10 to +20 percent. Note that the numbers gradually become more positive when following the curve from right to left (going back in time). This result is expected because, while the projection is a number based on the building area of a static list of buildings, actual building area (and therefore consumption) were smaller in past years.

Also, another analysis (not shown) indicated that building electrical use per square foot was lower in past years, causing the more current typical building data base to overestimate electrical usage for past years.

Peak Kilowatt Demand

Column 3 of Table 5 shows the actual peak kilowatt demand taken from utility bills for 1986 through 1988. Column 6 shows projected peak kilowatt demand for the same time periods. To calculate Column

6, USACERL used the value of 1689 kW peak demand which was obtained by finding the maximum hourly value on the total profile curve for all of Hohenfels. Column 6 was calculated by multiplying column 3 times the monthly multiplier (Column 5). Column 8 shows the percent difference between projected and actual. A positive quantity indicates that a higher kilowatt demand was projected than actually occurred. Column 8 is shown graphically in Figure 5. Note that, similar



Month	Monthly Multiplier
JAN	1.082
FEB	1.058
MAR	1.137
APR	1.003
MAY	0.910
JUN	0.909
JUL	0.898
AUG	0.889
SEP	0.904
OCT	1.058
NOV	1.076
DEC	1.011

Figure 3. Hohenfels and Grafenwöhr monthly average kilowatt-hour usage with combined average.

Table 5

Comparison of Projected to Actual Electrical Consumption at Hohenfels

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Actual meter data						% Diff.	% Diff.
Year	Month	kW	Total kWh	Multi- plier	Projected kW Peak	Projected kWh (month)	Proj. to Actual kW	Proj. to Actual kWh
1986	JAN	1582.0	879145	1.082	1827	984410	15.5	12.0
1986	FEB	1660.8	844210	1.058	1787	865038	7.6	2.5
1986	MAR	1418.7	747287	1.137	1920	1022277	35.4	36.8
1986	APR	1515.4	777820	1.003	1694	881713	11.8	13.4
1986	MAY	1334.8	678285	0.910	1537	823052	15.1	21.3
1986	JUN	1414.8	680433	0.909	1535	794214	8.5	16.7
1986	JUL	1385.1	692200	0.898	1517	817006	9.5	18.0
1986	AUG	1363.6	709150	0.889	1502	799300	10.1	12.7
1986	SEP	1444.2	762610	0.904	1527	794685	5.7	4.2
1986	OCT	1510.0	839205	1.058	1787	962575	18.3	14.7
1986	NOV	1641.5	795400	1.076	1817	934366	10.7	17.5
1986	DEC	1694.5	869705	1.011	1708	919814	0.8	5.8
1987	JAN	1621.6	907740	1.082	1827	978618	12.7	7.8
1987	FEB	1616.3	857720	1.058	1787	865038	10.6	0.9
1987	MAR	1591.0	886455	1.137	1920	1028363	20.7	16.0
1987	APR	1630.9	913095	1.003	1694	881713	3.9	-3.4
1987	MAY	1486.6	688265	0.910	1537	818181	3.4	18.9
1987	JUN	1416.0	723568	0.909	1535	799080	8.4	10.4
1987	JUL	1782.8	898790	0.898	1517	817006	-14.9	-9.1
1987	AUG	1498.2	697965	0.889	1502	799300	0.2	14.5
1987	SEP	1446.9	678551	0.904	1527	794685	5.5	17.1
1987	OCT	1542.9	811775	1.058	1787	956911	15.8	17.9
1987	NOV	1706.3	855310	1.076	1817	940126	6.5	9.9
1987	DEC	1751.8	918458	1.011	1708	919814	-2.5	0.1
1988	JAN	1769.3	812665	1.082	1827	972826	3.3	19.7
1988	FEB	1758.1	887060	1.058	1787	897550	1.6	1.2
1988	MAR	1990.3	1121051	1.137	1920	1034449	-3.5	-7.7
1988	APR	1801.8	712165	1.003	1694	876344	-6.0	23.1
1988	MAY	1732.1	794715	0.910	1537	823052	-11.3	3.6
1988	JUN	1771.5	892068	0.909	1535	799080	-13.3	-10.4
1988	JUL	1554.3	714870	0.898	1517	807392	-2.4	12.9
1988	AUG	1703.8	817115	0.889	1502	808818	-11.9	-1.0
1988	SEP	1652.4	838527	0.904	1527	794685	-7.6	-5.2
1988	OCT	1784.5	835795	1.058	1787	951248	0.1	13.8
1988	NOV	1964.9	962735	1.076	1817	945886	-7.5	-1.8
1988	DEC	2257.8	1038808	1.011	1708	914402	-24.4	-12.0

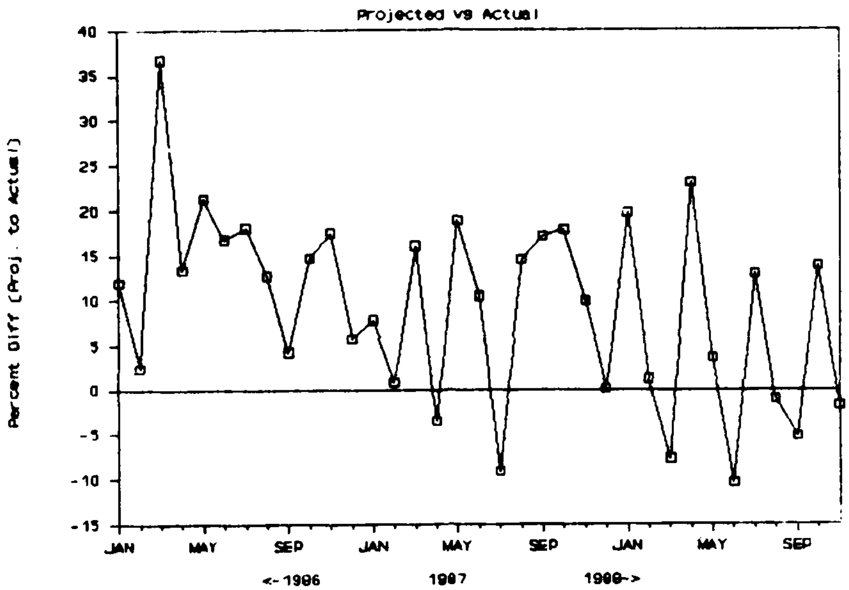


Figure 4. Percent difference for Hohenfels projected vs. actual kilowatt-hour usage, 1986 through 1988.

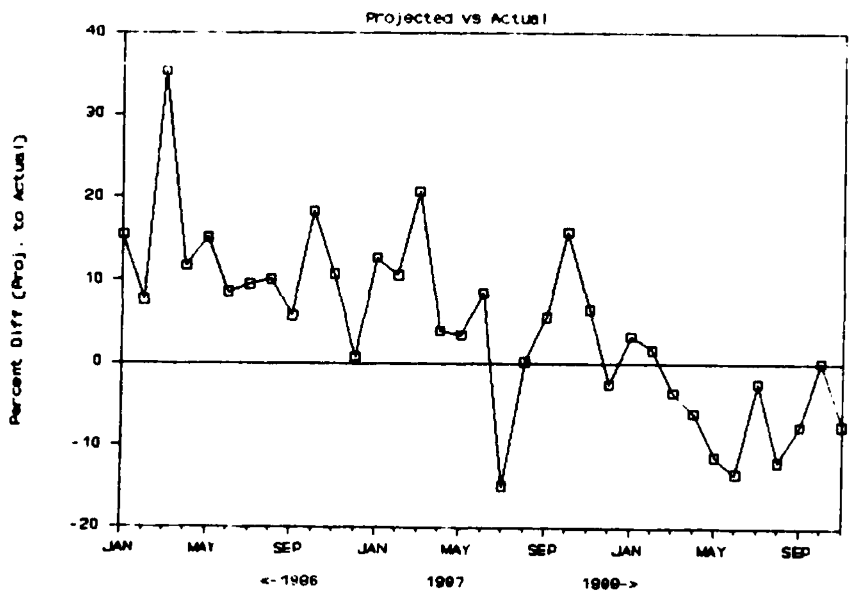


Figure 5. Hohenfels projected vs. actual monthly kilowatt peak demand--percent difference.

to the kilowatt-hour graph in Figure 4, the numbers become more positive when following the curve right to left. The reasons for the slope are assumed to be the same as cited above for the kilowatt-hour curve. The 1988 projected peak demand values compared with actual values range from -13 to +3 percent while all but one of the 1987 values are in the range -3 to +21 percent.

Hour-by-Hour Demand Profile

Hourly demand data at Hohenfels were obtained for November 1988 and January 1989. The average profile was obtained by averaging all of the 0100 hour readings during the month, all of the 0200 hourly readings, and likewise for each hour of the 30 or 31 days of data for each month. Separate averages were calculated for weekdays and weekend days. These calculated average profiles from actual meter data were then compared with the projected total installation profile calculated from the typical building data base information. Figure 6 shows the November and January weekday profiles compared with the projected weekday profiles. Figure 7 compares actual November and January weekend profiles with projected weekend profiles.

Grafenwöhr's Actual Consumption vs. Projections Using "Typical" Building Data

To examine how well Grafenwöhr's electrical consumption could be projected using the typical building information derived from both Hohenfels and Grafenwöhr, actual consumption from utility bills and projected consumption were compared. Actual vs. projected consumption were compared for total installation-wide monthly kilowatt-hour consumption, monthly peak demand, and hour-by-hour demand for two specific time periods.

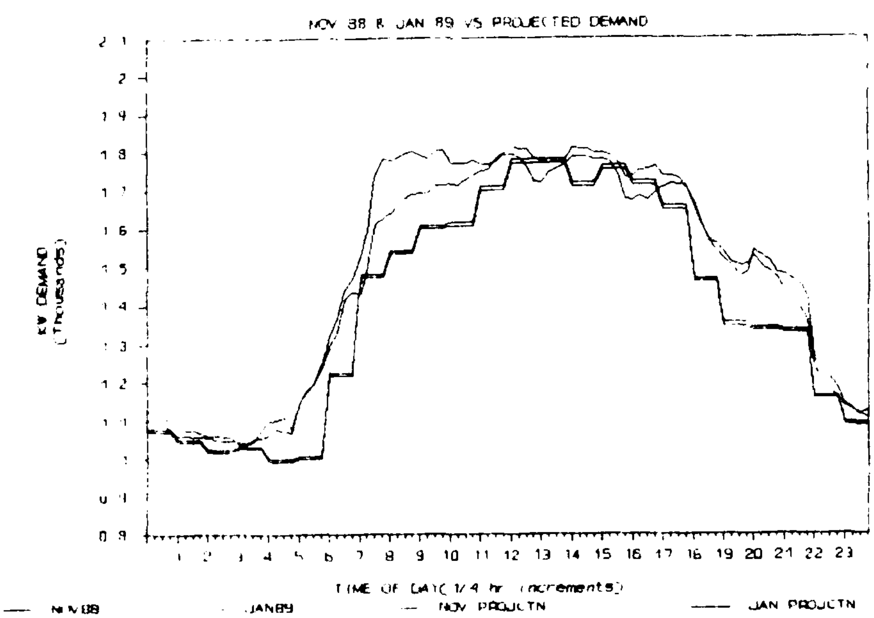


Figure 6. Hohenfels weekday demand profile, projected vs. actual.

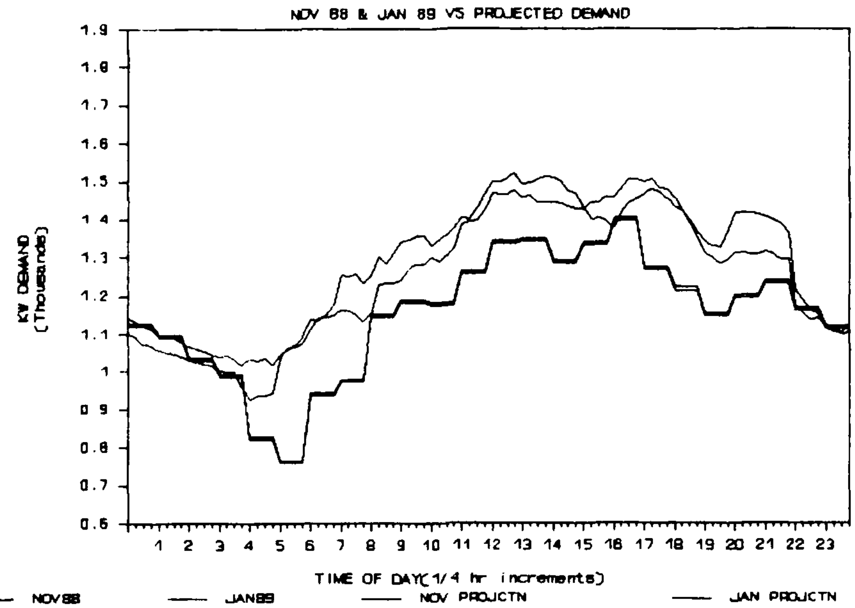


Figure 7. Hohenfels weekend demand profile, projected vs. actual for November 1988 and January 1989.

Total Kilowatt-Hours

Column 4 of Table 6 shows actual kilowatt-hour consumption for 1986 through 1988. Column 7 shows the consumption projected for the same time periods. Column 7 used the projection numbers 30,730 and 25,377 kWh/day for weekdays and weekends, respectively. These weekday and weekend numbers were calculated as described above for Hohenfels. Column 9 is the percent difference between projected and actual. A positive quantity indicates that more electrical usage was projected than actually occurred. Column 9 is shown graphically in Figure 8. Most of the consumption projections compared with actual values are in a range of -14 to +16 percent.

Peak Kilowatt Demand

Column 3 of Table 6 shows actual peak kilowatt demand taken from utility bills for 1986 through 1988. Column 6 lists projected peak kilowatt demand for the same time period. To calculate Column 6, USACERL used the value 1689 kW peak demand which was obtained by finding the maximum hourly value on the total profile curve for all of Grafenwöhr. Column 6 was calculated by multiplying column 3 by the monthly multiplier (Column 5). Column 8 shows the percent difference between projected and actual values. A positive quantity indicates that a higher kilowatt demand was projected than actually occurred. Column 8 is shown graphically in Figure 9. The 1988 projected peak demand values compared with actual values range from -22 to +8 percent.

Table 6

Comparison of Projected vs. Actual Electrical Consumption at Grafenwöhr

(1) Year	(2) Actual meter data Month	(3) kW	(4) Total kWh	(5) Multi-plier	(6) Projected kW Peak	(7) Projected kWh (month)	(8) % Diff. Proj. to Actual kW	(9) % Diff. Proj. to Actual kWh
1986	JAN	4559.3	2413300	1.082	3918	2239604	-14.1	-7.2
1986	FEB	4468.2	2279665	1.058	3831	1971054	-14.3	-13.5
1986	MAR	3890.0	2011717	1.137	4117	2334168	5.8	16.0
1986	APR	3692.7	2000979	1.003	3632	2006919	-1.6	0.3
1986	MAY	3294.9	1798612	0.910	3295	1875870	0.0	4.3
1986	JUN	3566.0	1647515	0.909	3291	1811126	-7.7	9.9
1986	JUL	3371.0	1730044	0.898	3252	1858747	-3.5	7.4
1986	AUG	3455.6	1238112	0.889	3219	1825044	-6.8	47.4
1986	SEP	3644.1	1827435	0.904	3273	1808828	-10.2	-1.0
1986	OCT	3557.7	1965000	1.058	3831	2189927	7.7	11.4
1986	NOV	4087.2	2010713	1.076	3896	2134741	-4.7	6.2
1986	DEC	4025.6	2087029	1.011	3661	2092643	-9.1	0.3
1987	JAN	4267.4	2247136	1.082	3918	2230430	-8.2	-0.7
1987	FEB	4116.3	2105275	1.058	3831	1971054	-6.9	-6.4
1987	MAR	4217.6	2381805	1.137	4117	2343807	-2.4	-1.6
1987	APR	4145.0	2181231	1.003	3632	2006919	-12.4	-8.0
1987	MAY	3626.8	1658843	0.910	3295	1868155	-9.1	12.6
1987	JUN	3358.9	1616006	0.909	3291	1818833	-2.0	12.6
1987	JUL	3268.9	1808661	0.898	3252	1858747	-0.5	2.8
1987	AUG	3800.0	1709336	0.889	3219	1825044	-15.3	6.8
1987	SEP	3885.5	1781913	0.904	3273	1808828	-15.8	1.5
1987	OCT	3683.9	2021277	1.058	3831	2180957	4.0	7.9
1987	NOV	4064.1	2120146	1.076	3896	2143863	-4.1	1.1
1987	DEC	4302.3	2329293	1.011	3661	2092643	-14.9	-10.2
1988	JAN	4299.2	2155187	1.082	3918	2221257	-8.9	3.1
1988	FEB	4265.3	2232720	1.058	3831	2044012	-10.2	-8.5
1988	MAR	4560.0	2676200	1.137	4117	2353447	-9.7	-12.1
1988	APR	3890.0	1825195	1.003	3632	1998415	-6.6	9.5
1988	MAY	3812.1	1885430	0.910	3295	1875870	-13.6	-0.5
1988	JUN	3834.0	1869155	0.909	3291	1818833	-14.1	-2.7
1988	JUL	3684.8	1894670	0.898	3252	1843520	-11.8	-2.7
1988	AUG	3743.2	1939660	0.889	3219	1840118	-14.0	-5.1
1988	SEP	3857.9	2000675	0.904	3273	1808828	-15.2	-9.6
1988	OCT	4026.0	2113920	1.058	3831	2171987	-4.8	2.7
1988	NOV	4540.9	2393870	1.076	3896	2152986	-14.2	-10.1
1988	DEC	4665.6	2369507	1.011	3661	2084071	-21.5	-12.0

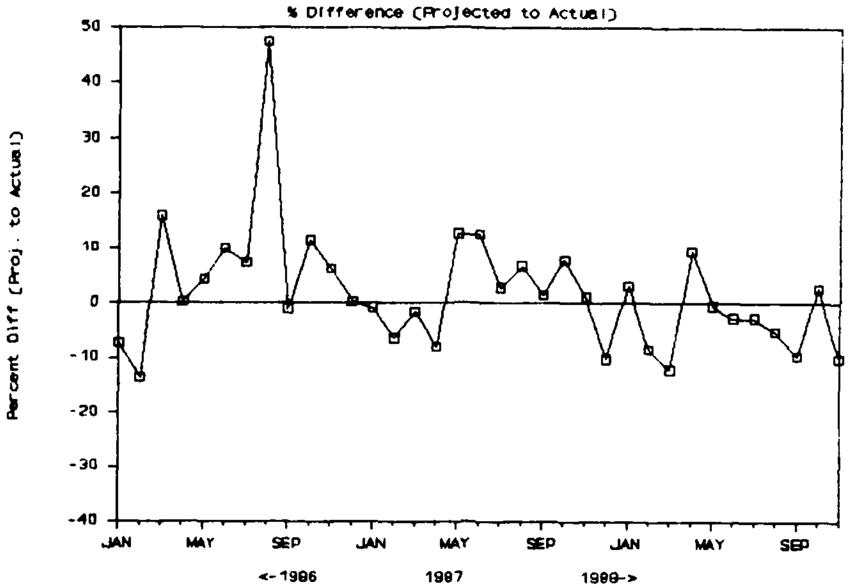


Figure 8. **Percent difference in Grafenwöhr projected vs. actual kilowatt-hour usage, 1986 through 1988.**

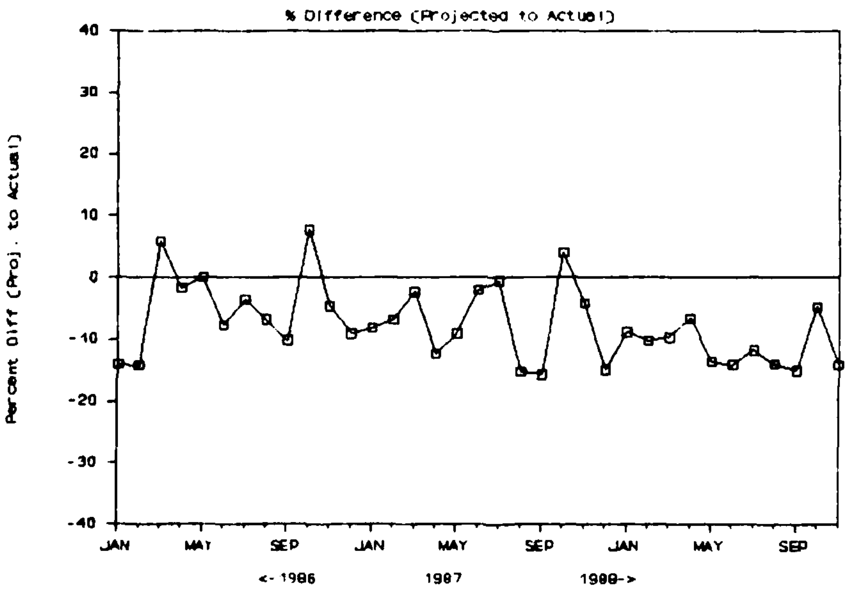


Figure 9. **Percent difference of Grafenwöhr projected vs. actual kilowatt peak demand, 1986 through 1988.**

Hour-by-Hour Demand Profile

Hourly demand data at Grafenwöhr were obtained for November 1988 and January 1989. The average profile was calculated by averaging all of the 0100 hour readings during the month, all of the 0200 hourly readings, and likewise for each hour of the 30 or 31 days of data for each month. Separate averages were calculated for weekdays and weekend days. These average profiles calculated from actual meter data were then compared with the projected total installation profile calculated from the typical building data base information. Figure 10 shows the November and January weekday profiles compared with the projected weekday profiles. Figure 11 shows November and January weekend profiles compared with projected weekend profiles.

Use of Consumption Projection Data Base for Amberg

In an initial attempt to use the typical building data base outside of Hohenfels and Grafenwöhr, the Amberg community building list (as of June 1989) and recent meter data were obtained. The building list of less than 100 buildings was used along with the typical building data base to project electrical consumption for the Amberg community.

Table 7 lists projected versus actual kilowatt-hour consumption for a 1-year period ending May 1989. Positive numbers in the percent difference column indicate that projected kilowatt-hour consumption was greater than actual. Except for the November 1988 number, projected to actual ranged from -5 to +9 percent. The November exception of +26 percent resulted from an unexplained low kilowatt-hour consumption for the month.

Also shown in Table 7 is projected peak versus actual peak kilowatts. The negative numbers ranging from -32 to -11 percent indicate that projected was less than actual. Underestimating the monthly peak

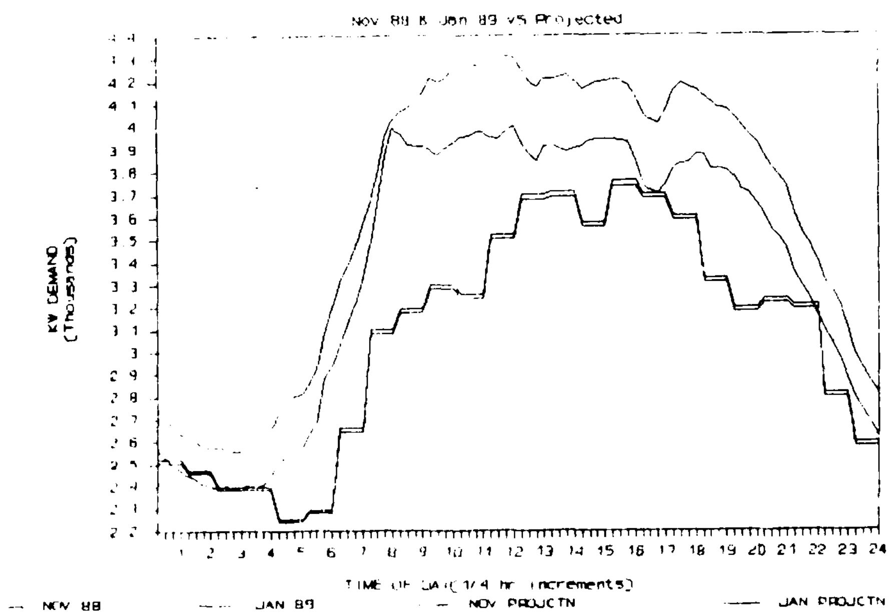


Figure 10. Grafenwöhr weekday demand profile, projected vs. actual.

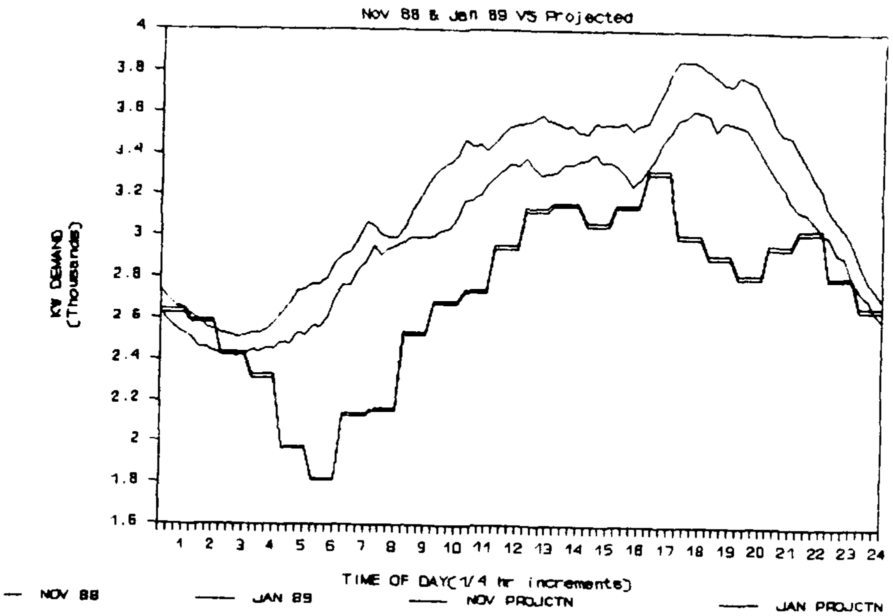


Figure 11. Grafenwöhr weekend demand profile, projected vs. actual.

is somewhat expected (though not yet determined to be predictably quantifiable). The projected peak is the maximum point on a profile for a *typical* consumption day while the actual peak kilowatts is the highest 15-min demand for an entire month. Also contributing to the underprojection could be the way in which actual peak data were derived--by adding the monthly peak for two separate utility meters (Pond Barracks and Amberg Family Housing). A direct addition of the two peaks, which probably did not occur coincident in time, yields a greater peak than one meter would register if both locations were truly metered together.

Table 7

Comparison of Projected to Actual Electrical Consumption at Amberg

Year	Month	Projected kWh	Actual kWh*	% Diff.	Projected kW	Actual kW*	% Diff.
88	MAY	388584	379240	2.46	659	898.8	-26.67
88	JUN	376563	378808	-0.59	658	862.8	-23.69
88	JUL	382169	377224	1.31	650	906	-28.21
88	AUG	380894	353508	7.75	644	910	-29.24
88	SEP	374491	364084	2.86	655	938.4	-30.22
88	OCT	450261	417496	7.85	766	982	-21.96
88	NOV	445744	351016	26.99	779	1002.4	-22.25
88	DEC	431712	452088	-4.51	732	941.2	-22.20
89	JAN	462030	426684	8.28	784	901.2	-13.04
89	FEB	408257	390200	4.63	766	966	-20.67
89	MAR	487150	448704	8.57	824	927.6	-11.22
89	APR	412620	393828	4.77	726	975.2	-25.50
89	MAY	389891	360280	8.22	659	970.4	-32.08
89	JUN	376563	381720	-1.35	658	772	-14.71

*Actual data are combined Pond Barracks and Amberg Family Housing data.

3 AUTOMATED (PC) CHECKS OF MONTHLY METER DATA

When electrical kilowatt-hour meters are installed at Army facilities, a large quantity of useful information becomes available for managing electrical consumption. However, this mass of information (commonly in the form of monthly meter readings) is useful only after time-consuming manipulation and analysis. In an attempt to reduce the amount of time needed for analysis, some of the end uses (checks) of monthly meter data were identified and a procedure was developed for automating these checks.

Automated data check procedures were established for the following conditions:

1. Seasonal Trends: building consumption is cyclic; increasing/decreasing with the seasons of the year.

2. Growth Trends: Long-Term--building consumption is growing from last year to this year. Short-Term--building consumption has shown consistent increases in the two most recent months.

3. Extreme Variation: this month's consumption is radically different than the trend of the previous several months.

4. Reasonable Consumption Level: building consumption is reasonable compared with projected "typical" consumption for a building of this type (as found in the built-in data base of typical buildings).

Preliminary Assumptions and Definitions

The four conditions for which data are being checked can be readily detected by observing line graphs of the data. It was this ease in *visually* observing trends on graphs that provided the initial stimulus for developing automated detection of trends. First considerations on how to detect trends involved a brief look at mathematically describing (with trigonometric functions) the curves seen on the graph and then evaluating the coefficients to the functions to detect the trend. However, this method seemed unnecessarily complicated compared with the simpler procedure of calculating seasonal averages and answering a series of questions based on comparisons of numbers. Thus, the following descriptions of trend detection procedures chiefly describe the calculations and the logic path for the series of questions to arrive at a yes/no answer as to whether the particular trend in question has been detected.

These data checks were established under the assumption that, before performing the checks, meter readings would be used to compute consumption for a calendar month. In the computer program, the computed calendar month consumption for the most recent 24 months is used in the calculations and questions to detect trends for each building. (Some trends, such as short-term growth, obviously do not need a full 24 months of consumption data.)

During development of these checks, it became desirable to group the 12 calendar months of each year into four seasons. Since these checks were being developed for use in the Federal Republic of Germany where summers are relatively short and mild, the seasons were defined as follows:

April, May	Spring
June, July, August	Summer
September, October	Fall
November through March	Winter

These season definitions are used to determine which months are grouped together for computation of seasonal average consumption. It is the seasonal average consumption numbers which are, for the most part, manipulated to arrive at pass/fail results during the monthly check.

In addition to separating months into seasons, each season of the most recent 24 months is assigned a numerical number, with the most recent (or current) season being defined as season 1. Thus, season 5 is the same season (spring, summer, etc.), only 1 year subsequent to season 1. Several example cases of how these season numbers would be assigned at various points in time are shown in Figure 12. The purpose of assigning sequential season numbers is to be able to clearly specify a particular season when communicating the method of checking data.

Detailed Description of Data Check Procedures

Seasonal Variation

Checking for "seasonal variation," as the name implies, compares consumption between the various seasons of the current year and the previous year. From this comparison, repetitious cyclic variations in consumption due to seasons are detected. Detection of seasonal variation is of particular interest for buildings without air-conditioning and/or electrical heating where presence of a strong seasonal peak is not expected; thus, seasonal variation may indicate undesirable occupant activity such as the use of low-efficiency supplemental heating/cooling.

Figure 13 shows the method of checking for seasonal variation. Several questions that compare various season averages determine the path to be followed to result in a Yes or No answer. In general terms, questions 1 a and b determine if a seasonal peak occurred 1 year ago. Questions 2 a, b, and c determine if a similar peak is occurring this year. Questions 3 a, and b ensure that the Yes answers to questions 1 and 2 are due to a peak and not to a continuously rising consumption (a problem to be detected elsewhere).

Growth Trend

Checking for "long-term growth" will detect gradually increasing electrical consumption from last year to this year by comparing the various seasons of the current year with those of the previous year. Long-term growth detection is shown in Figure 14a, where a Yes answer to three questions indicates long-term growth:

- Is there growth this season compared to a year ago?
- Is this year's average greater than last year's?
- Did at least two seasons show growth over the same seasons last year?

Checking for "short-term growth" will detect a more severe consumption increase occurring over the most recent 3 months. Short-term growth detection is shown in Figure 14b. The check simply determines if this month's consumption is greater than last month's, and also if last month's was greater than the preceding month's. If so, short-term growth exists.

Extreme Variation

Checking for "extreme variation" will detect erratic electrical consumption from month to month which may warrant investigation into the causes for such a pattern. As shown in Figure 15, abnormal is variation detected by answering two questions. First, is this month's consumption more than +/- xx percent of last month's? Second, to avoid a Yes condition at the month when the consumption returns to normal, is this month's consumption more than +/- xx percent of the prior month's average?

	EXAMPLE 1	EXAMPLE 2
Latest monthly reading =	Feb _9	Sep _8
SEASON NUMBER	MONTHS TO AVG.	MONTHS TO AVG.
SEASON ONE (S1)	Feb _9 Jan _9 Dec _8 Nov _8	Sep _8
SEASON TWO (S2)	Oct _8 Sep _8	Aug _8 Jul _8 Jun _8
SEASON THREE (S3)	Aug _8 Jul _8 Jun _8	May _8 Apr _8
SEASON FOUR (S4)	May _8 Apr _8	Mar _8 Feb _8 Jan _8 Dec _7 Nov _7
SEASON FIVE (S5)	Mar _8 Feb _8 Jan _8 Dec _7 Nov _7	Oct _7 Sep _7
SEASON SIX (S6)	Oct _7 Sep _7	Aug _7 Jul _7 Jun _7
SEASON SEVEN (S7)	Aug _7 Jul _7 Jun _7	May _7 Apr _7
SEASON EIGHT (S8)	May _7 Apr _7	Mar _7 Feb _7 Jan _7 Dec _6 Nov _6

Figure 12. Examples of "past seasons" definitions for meter data checking.

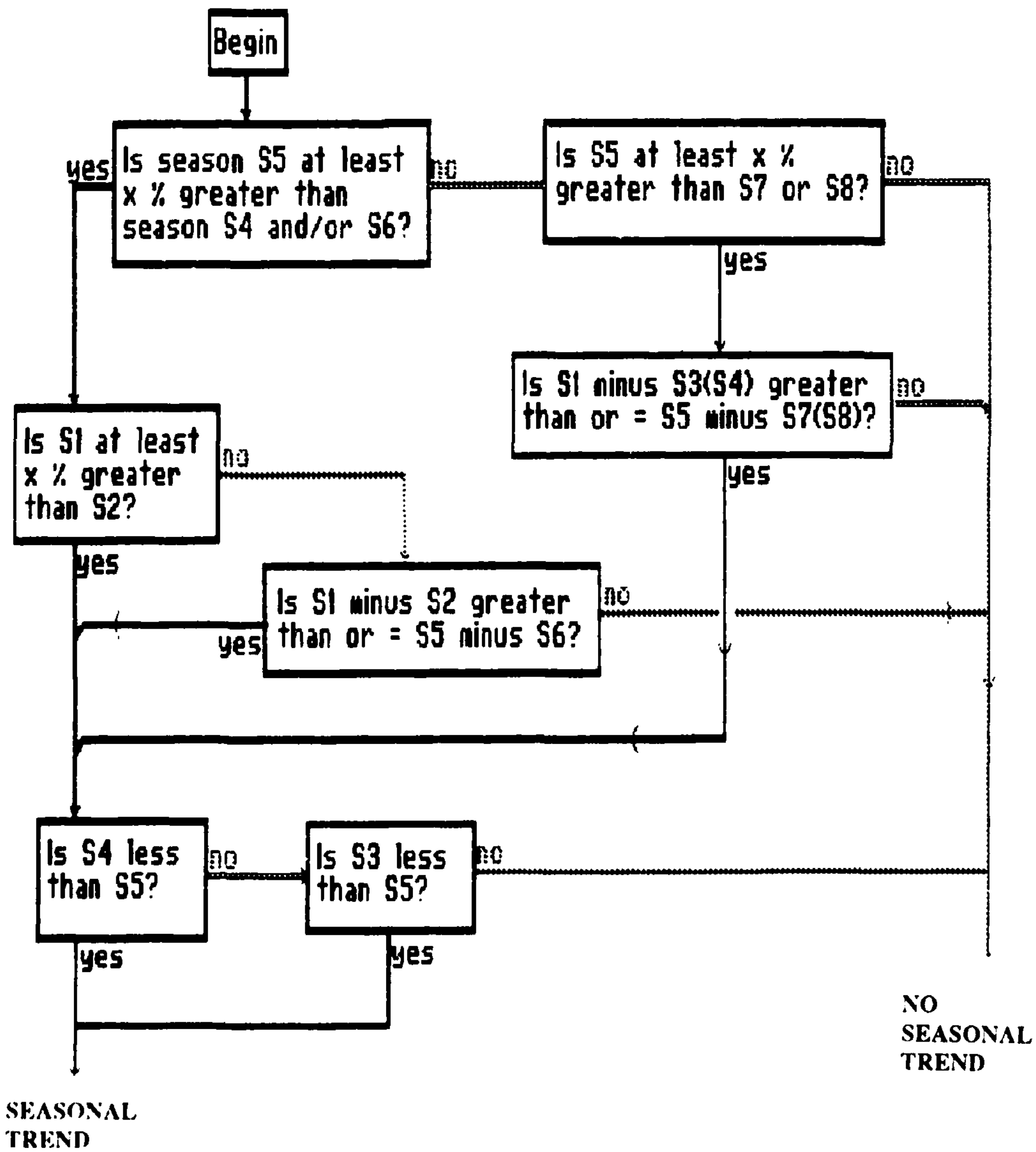
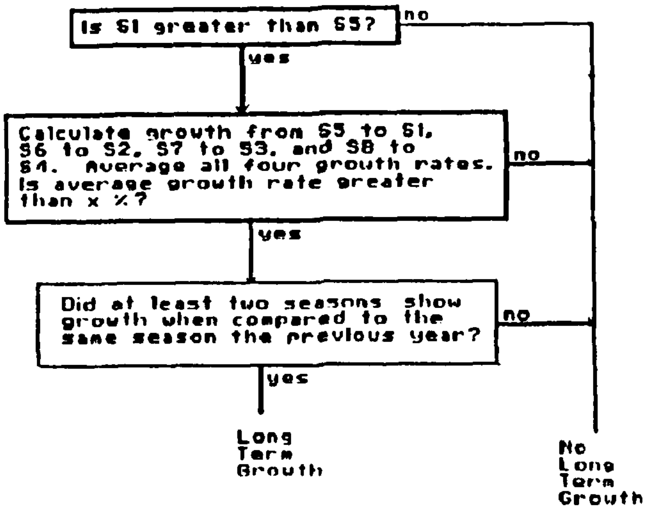
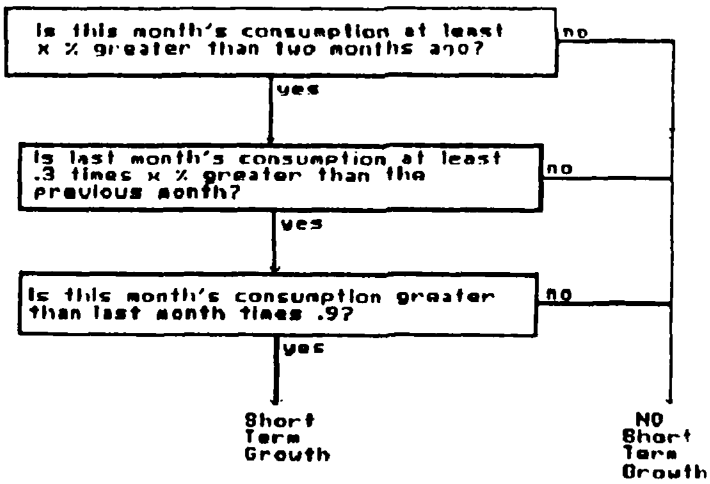


Figure 13. Logic diagram for seasonal variation check of monthly meter data.



(a)



(b)

Figure 14. Logic diagram for (a) long-term growth check of monthly meter data, and (b) short-term growth check of monthly meter data.

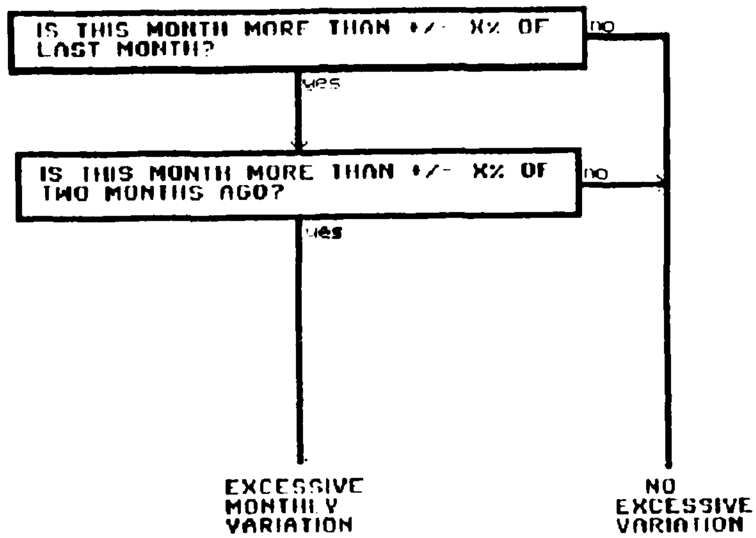


Figure 15. Logic diagram for abnormal variation check of monthly meter data.

Reasonable Consumption Level

Checking for "reasonable consumption level" will detect an unexpected consumption level for a given building with a specific function compared with a data base of "typical" consumption for various types of buildings. (Note: the accuracy of the data base used for comparison is not critical since it is being used only as an approximate "benchmark" for comparison. However, realistic data base numbers are needed to avoid being inundated with meaningless alarms.)

Reasonable consumption is determined by comparing this month's consumption (divided by the area of the building being checked) with an expected kilowatt-hour per square foot consumption number for a given building type. If this month's consumption is more than +/- xx percent from the expected, an unreasonable consumption level is declared. An unreasonable consumption alarm is intended to provide incentive to more closely examine the operation of specific buildings. If, upon investigation, it is apparent that consumption is reasonable, it may be appropriate (depending on conditions) to take actions such as increase the +/- tolerance level, alter the expected kilowatt-hour per square foot value for this building, or no longer perform this check for this building.

All of the above checks on monthly meter readings are intended only as a tool to detect potential problem areas, without specifying the cause of the problem or suggested solutions. The first three checks were selected and defined to collectively detect a variety of conditions without giving multiple redundant alarms. For example, if the most recent month's consumption showed a sudden increase, seasonal variation would first check to see if the increase was part of a repetitive seasonal cycle. If not, then the resultant alarm would be an "abnormal variation" alarm. If, in the following month, consumption continued at the same high level or higher, the resultant alarm would be "short-term growth." Eventually, if the higher consumption level continued, the alarm would be "long-term growth." This example indicates the collective operation of the first three data checks. The fourth data check ("reasonable consumption level") operates independently of the first three.

In the computer program, each of the checks will permit the user to specify tolerance limits, which will be used to determine pass/fail results of the check.

4 DEVELOPMENT OF A PC PROGRAM TO PROJECT ELECTRICAL CONSUMPTION AND CHECK MONTHLY METER DATA

Using the typical building data base and the monthly meter check procedures developed in Chapters 2 and 3, a PC-based computer program is being developed to:

1. Project electrical consumption.

2. Check monthly meter readings.

An initial version of the program was completed in March 1990.

Using the profiles and subprofiles established in Chapter 2 as "typical" for each building type, it is possible to project electrical consumption for other, similar buildings. The main user input requirement for this program is a building list that includes the building number, description (optional), the five-digit Army category code, and gross building area in square feet for each building. Typically, it is expected that the list will be the entire installation building list available from the local DEH Property Office. The consumption projection is made by multiplying the hour-by-hour numbers (in kilowatt-hours per square foot) of the appropriate profile by the area (in square feet) of the building for which the projected consumption is desired.

Using the procedures described in Chapter 3, it is possible to perform checks of monthly meter readings. The user can input raw meter readings and dates or calculated consumption for past calendar months. As a history of data for a particular metered building is accumulated, consumption checks are automatically performed as new readings are added. The results of the checks are lists of metered buildings where the current meter readings indicate alarming trends.

The program is currently called ELECTER. It is written in a data base program language but compiled such that the user is not required to own the data base software. Hardware requirements are an IBM-compatible PC with at least 380 KB of available random access memory (RAM). The main menu options for the computer program are: Locations, Meters, Review, Usage, and Projection.

The Locations option allows a user to input a list of buildings for an entire installation or any subset of buildings (such as buildings that have electrical meters). The list can be entered through the computer keyboard or from Lotus or dBase files. These defined building lists can be used for consumption projections and/or as a list for monthly meter data checking. In addition, the user can edit and view the current list or previously entered building lists. If desired, a printout of the current building list can be obtained.

The Meters selection allows the user to input the electrical meter readings for a building list. The meter readings can be entered directly through the keyboard or through Lotus or dBase files. This option also permits the user to edit and view the current and previously entered readings. Moreover, the user can obtain a printout of the meter readings by specifying the desired timeframe (From,To).

The Review option has two main features. The first feature deals with energy usage data (meter readings). By selecting a building or meter list from the user's data bases, energy consumption can be calculated from the meter data. Also, the user can view and edit previously calculated energy usage as well as the building category lists. The second feature involves looking at the projection data. This is the typical building information developed and entered by USACERL (described in Chapter 2). The category list can be viewed by profile or category code. Furthermore, weekday and weekend profiles can be viewed, as can typical building loads.

The Usage option is associated solely with monthly meter data checking. Thus, only metered buildings apply to this option. Building meter data are checked for some or all of the following: seasonal variation, long-term growth, short-term growth, monthly variation, and reasonable consumption. Building data that exceed the specified alarm limits are listed on an alarm list. The alarm limits can be designated by the user (or default settings can be used) and can be specified globally or for each individual building. These alarm lists can be viewed on a computer monitor or printed on a printer. Building alarm lists can be obtained by specifying building number, alarm type, building type, or the standard output report. This standard report can be filed and/or printed.

The Projection option produces a set of projected consumption breakouts for a specified building list. The user can specify a variety of output lists and/or graphs that indicates electrical usage by major function (e.g., utilities, military), by more specific building categories (e.g., administration, storage, etc.), or by load type (e.g., lighting, motors). Other possible outputs include projected 24-hr consumption profiles for weekday or weekend and lists of projected major building consumers at peak and off-peak hours. A standard output report is available. The user specifies the desired time period on which the projections will be based. The generated reports can be printed and/or filed.

5 EVALUATION OF ELECTRICAL CONSUMPTION AT HOHENFELS

Hohenfels Historical Monthly Kilowatt-Hour Consumption

Table 8 shows monthly electrical utility billing information for the Hohenfels cantonment area main meter from 1981 through 1988. Figure 16 shows the Hohenfels annual kilowatt-hour usage for 1981 through 1988. Note that over the 6 years, annual use has grown 45 percent (average 7.4 percent per year). Figure 17 shows monthly kilowatt-hour use for several years. From the graph, consumption trends are not obvious. However, when each monthly reading is averaged with the same month's readings from other years (shown in Figure 18), a trend can be seen. Figure 18 indicates a higher winter kilowatt-hour consumption during October through March, a transition to lower consumption in April, and a lowered summer consumption during May through September. This trend is not surprising in light of the relatively low summer air-conditioning load and the greater winter loads due to heating requirements, increased use of lighting to offset the reduced winter daylight, and some supplemental electrical space heating (unauthorized, in some cases). Some individual months do not follow this general trend. Looking at Figure 17 again, June 1985, July 1987, and June 1988 are summer months that did not follow the trend. Total cost for electricity (including demand charges) for 1987 was 1,474,415 DMarks (about $775K @ 1.9 DMarks/$).

Hohenfels Monthly Peak Demand

The utility billing data in Table 8 indicates the peak kilowatt demand at Hohenfels for each month. As is common in electricity rate structures, the customer must pay not only for the energy (kwh) used, but also for the peak load (kW) during specified time intervals. The peak demand numbers indicate the highest average demand (kW) during any 15-min interval of the month. To compute the annual demand charge, the peak demand numbers from the highest 2 months are averaged together. This 2-month average is multiplied by the demand charge rate (currently 232.8 DMarks/kW) to arrive at the annual demand charge. Although the highest 2 months cannot be known until the final month of the calendar year (and therefore the exact charge cannot be computed monthly during the year), some reasonable portion of the expected annual demand charge is paid each month and contributes to the final charge to be levied at the end of December each year. For the years 1981 through 1987, demand charges constituted 30 percent (average) of the total electricity cost.

Since demand charges are a significant portion of total electricity costs, a closer examination of demand trends is needed. Figure 19 graphs the monthly peak demand at Hohenfels for 1984 through 1988. One question of interest is whether the two highest demand months occur repeatedly in the same month each year. Three of the years (81, 82, 84) had their two high months in November and December. Of the 16 "high" months for the 8 years of data, 11 of 16 high months occurred in November or December. Three of 16 were in February or March (still winter season). The remaining two peak demand months were unexpectedly in May (85) and July (87).

Also interesting is the lack of extremity of the peak months compared with other months. This lack of extremity means that major peak shaving actions during peak months may leave other months as peaks, requiring peak shaving actions in additional months. Table 9 shows, for various quantities (kW) of peak shaving in column 4, the number of months requiring peak shaving actions (column 6) and the resulting savings in electrical demand charges (column 5) for several past years. As expected, the number of months affected by peak shaving actions increases as the kilowatts of shaving increase. The number of affected months also increases in years that lack extremity between monthly peaks. Data for 1981 through 1988 are averaged and shown in the summary columns (labeled "average year") to provide a "feel" for the savings potential. As an example, for a peak demand reduction of 100 kW, the average savings would have been 17,222 DMarks, with the reduction actions required in approximately 4 months of the year.

Table 8

Hohenfels Electricity Use Data, 1981-88

Year	Month	Peak kW	Total kWh	Year	Month	Peak kW	Total kWh
1981	JAN	1200	644360	1985	JAN	1303.6	730570
1981	FEB	1256	588320	1985	FEB	1266.2	635775
1981	MAR	1164	580320	1985	MAR	1358.8	699172
1981	APR	1080	571700	1985	APR	1356.3	649260
1981	MAY	872	478200	1985	MAY	1440.9	585675
1981	JUN	848	485760	1985	JUN	1393.7	788679
1981	JUL	828	535400	1985	JUL	1076.6	418130
1981	AUG	876	548400	1985	AUG	1247.8	611695
1981	SEP	1080	481700	1985	SEP	1369.1	654132
1981	OCT	1052	608380	1985	OCT	1395.5	761650
1981	NOV	1280	610240	1985	NOV	1412.2	656815
1981	DEC	1356	670420	1985	DEC	1324.7	675020
1982	JAN	1332	683420	1986	JAN	1582.0	879145
1982	FEB	1364	671100	1986	FEB	1660.8	844210
1982	MAR	1368	680180	1986	MAR	1418.7	747287
1982	APR	1228	676380	1986	APR	1515.4	777820
1982	MAY	1268	604240	1986	MAY	1334.8	678285
1982	JUN	1172	532420	1986	JUN	1414.8	680433
1982	JUL	1028	554260	1986	JUL	1385.1	692200
1982	AUG	1184	572300	1986	AUG	1363.6	709150
1982	SEP	1096	550340	1986	SEP	1444.2	762610
1982	OCT	1304	683480	1986	OCT	1510.0	839205
1982	NOV	1396	651520	1986	NOV	1641.5	795400
1982	DEC	1396	687540	1986	DEC	1694.5	869705
1983	JAN	1288	636380	1987	JAN	1621.6	907740
1983	FEB	1352	661800	1987	FEB	1616.3	857720
1983	MAR	1352	820780	1987	MAR	1591.0	886455
1983	APR	1272	555480	1987	APR	1630.9	913095
1983	MAY	1224	622420	1987	MAY	1486.6	688265
1983	JUN	1112	553880	1987	JUN	1416.0	723568
1983	JUL	992	533520	1987	JUL	1782.8	898790
1983	AUG	1120	592920	1987	AUG	1498.2	697965
1983	SEP	1124	585060	1987	SEP	1446.9	678551
1983	OCT	1304	614040	1987	OCT	1542.9	811775
1983	NOV	1380	747800	1987	NOV	1706.3	855310
1983	DEC	1300	683500	1987	DEC	1751.8	918458
1984	JAN	1258	699020	1988	JAN	1769.3	812665
1984	FEB	1348	655980	1988	FEB	1758.1	887060
1984	MAR	1308	738080	1988	MAR	1990.3	1121051
1984	APR	1328	695000	1988	APR	1801.8	712165
1984	MAY	1292	590320	1988	MAY	1732.1	794715
1984	JUN	1276	563580	1988	JUN	1771.5	892068
1984	JUL	1128	577340	1988	JUL	1554.3	714870
1984	AUG	1180	587980	1988	AUG	1703.8	817115
1984	SEP	1280	521700	1988	SEP	1652.4	838527
1984	OCT	1336	686420	1988	OCT	1784.5	835795
1984	NOV	1512	759160	1988	NOV	1964.9	962735
1984	DEC	1417.3	664695	1988	DEC	2257.8	1038808

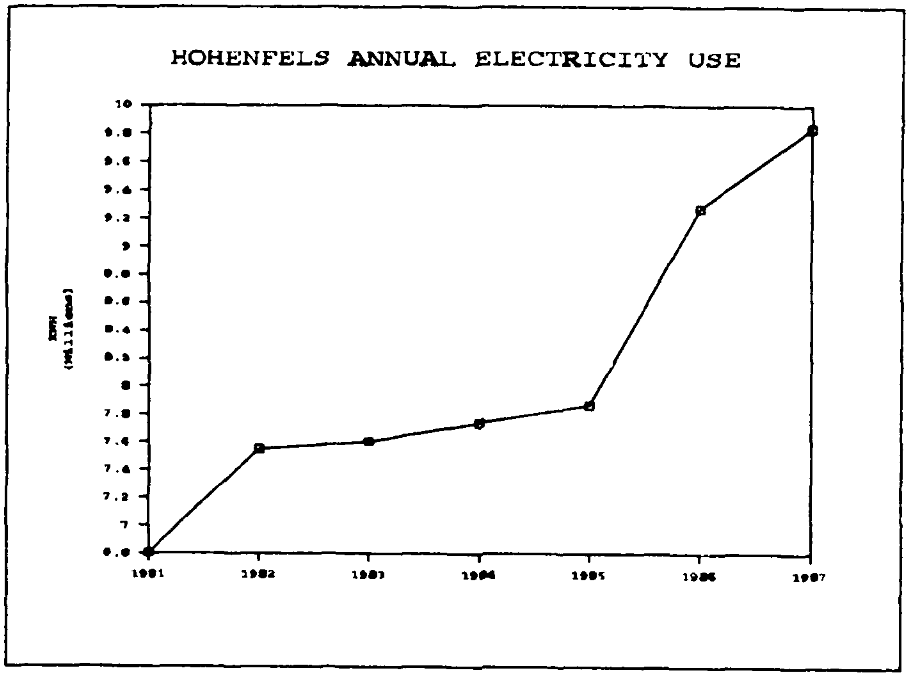


Figure 16. Hohenfels annual electricity usage, 1981-88.

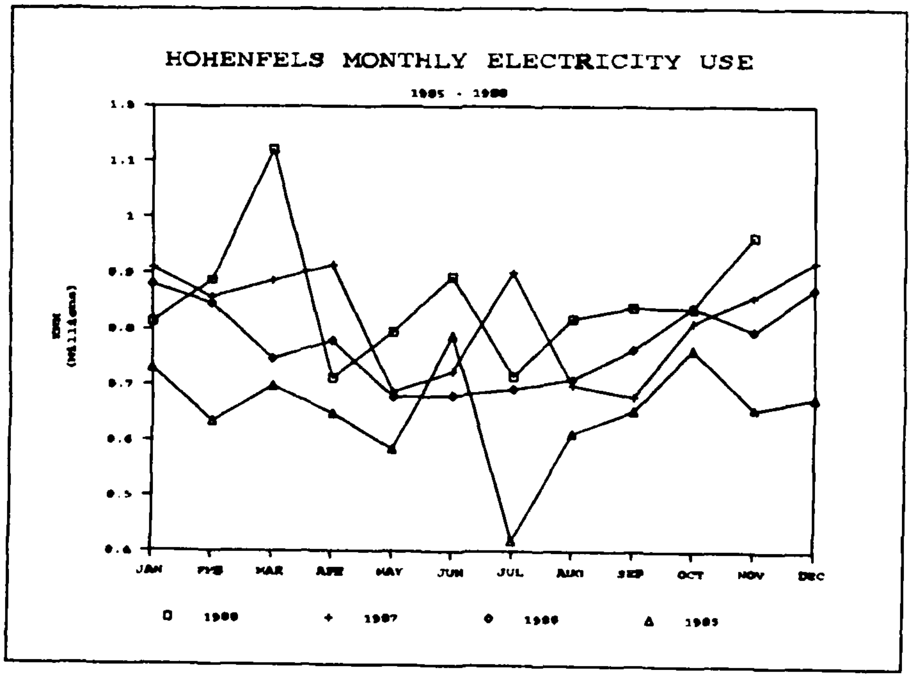


Figure 17. Hohenfels monthly kWh electricity usage, 1983-88.

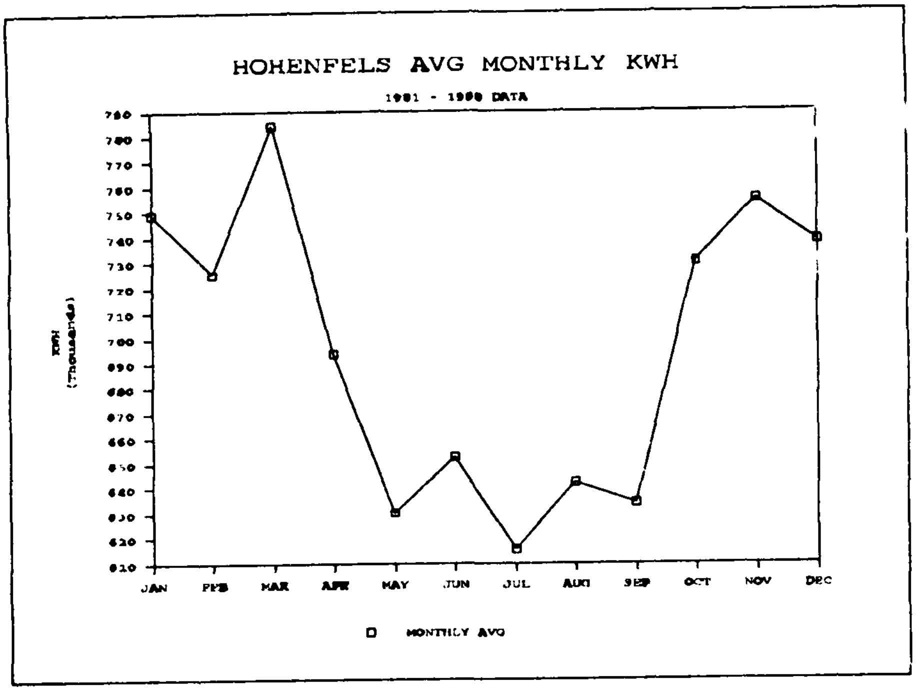


Figure 18. Hohenfels average monthly kWh usage, 1981-88 data for each month.

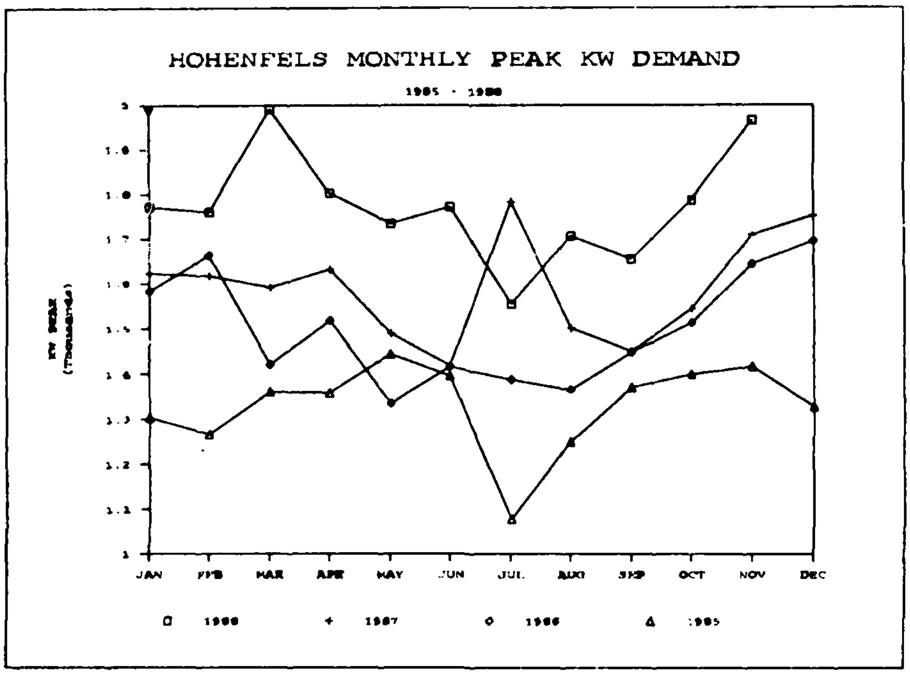


Figure 19. Hohenfels monthly peak kW demand for 1984-88.

Table 9

Hohenfels Required Months of Action for Peak Shaving

Year	Month	Peak kW	If kW Peak is Reduced by(kW):	Demand Savings Are (DMarks):	No. of Months Requiring Action
1986	DEC	1694.5			
1986	FEB	1660.8	20	2328	1
1986	NOV	1641.5	40	5389	2
1986	JAN	1582	60	10045	3
1986	APR	1515.4	80	14701	3
1986	OCT	1510	100	19357	3
1986	SEP	1444.2	120	24013	4
1986	MAR	1418.7	140	28669	4
1986	JUN	1414.8	160	33325	4
1986	JUL	1385.1			
1986	AUG	1363.6			
1986	MAY	1334.8			
1987	JUL	1782.8			
1987	DEC	1751.8	20	2328	1
1987	NOV	1706.3	40	5704	2
1987	APR	1630.9	60	10360	2
1987	JAN	1621.6	80	15016	3
1987	FEB	1616.3	100	19672	3
1987	MAR	1591	120	24328	3
1987	OCT	1542.9	140	28984	3
1987	AUG	1498.2	160	33640	4
1987	MAY	1486.6			
1987	SEP	1446.9			
1987	JUN	1416			
1988	DEC	2257.8			
1988	MAR	1990.3	20	2328	1
1988	NOV	1964.9	40	4656	1
1988	APR	1801.8	60	6984	1
1988	OCT	1784.5	80	9312	1
1988	JUN	1771.5	100	11640	1
1988	JAN	1769.3	120	13968	1
1988	FEB	1758.1	140	16296	1
1988	MAY	1732.1	160	18624	1
1988	AUG	1703.8			
1988	SEP	1652.4			
1988	JUL	1554.3			

Average Year (based on 1981-88 data)

If Peak Reduced (kW)	Savings (DMarks)	Months Requiring Action
20	2557	1.1
40	5676	2.0
60	9397	2.4
80	13169	3.1
100	17222	3.9
120	21489	4.3
140	25755	4.4
160	30022	4.8

Hohenfels Daily Peak Demand

The monthly peak demand numbers (discussed in the previous paragraph) are the maximum values taken from daily peaks occurring within each month. Just as attempts to reduce monthly peaks are affected by the extremity of the peak being reduced, attempts to reduce the daily peaks are affected by extremity of the peaks.

Data indicating the Hohenfels demand for each 15-min interval were obtained for two calendar months-- November 1988 and January 1989. Figures 20 and 21 show the daily demand curves for the successive eight highest peaks during November 1988 and January 1989, respectively. Also, shown on the graphs are two horizontal lines indicating a level 100 kW and 200 kW below the *monthly* peak demand. These graphs provide a visual indication of the peak shaving requirement for various reduction levels. For example, at the 100-kW level (below the monthly peak), four November days require peak shaving action (as indicated by peak curves 1 through 4). Peak curve 5 is more than 100 kW below the monthly peak with no peak shaving action. In January, all eight peak curves shown require some peak shaving to stay below the 100-kW level. From the same data that produced the graphs above for November 1988 and December 1989, Table 10 summarizes the number of days requiring peak shaving actions and the corresponding number of 15-min intervals for various peak shaving levels.

Consumption Projection Program Output

Another way to examine Hohenfels' electrical use is to use the data base of "typical" building consumption described in Chapter 2. A variety of usage "breakouts" is possible. A set of outputs (which are currently being programmed as standard format outputs in the PC-based program) is shown in Figures 22 through 32.

Figures 22 and 23 indicate that 39 percent of Hohenfels' projected monthly consumption is for military functions and more than half of the 39 percent is attributed to troop dining facilities. Within Troop Dining, most of the consumption (89 percent) is for mission-related equipment (i.e., food preparation/serving equipment). The other major military functions (consuming about 4 percent each) are the Airfield Area, Hutments, and the Centralized Wash Facility.

For Utilities, projected monthly consumption is 26 percent of the installation total. Major utility consumers are Heating Plants, Exterior Lighting, and the Installation Water Supply System, each accounting for about 7 percent of the installation monthly consumption. Other building categories consuming at least 4 percent of the installation projected monthly total are Storage (4.2 percent), the Commissary (4.2 percent), Family Housing (5.6 percent), and Gym/Recreational buildings (4.7 percent).

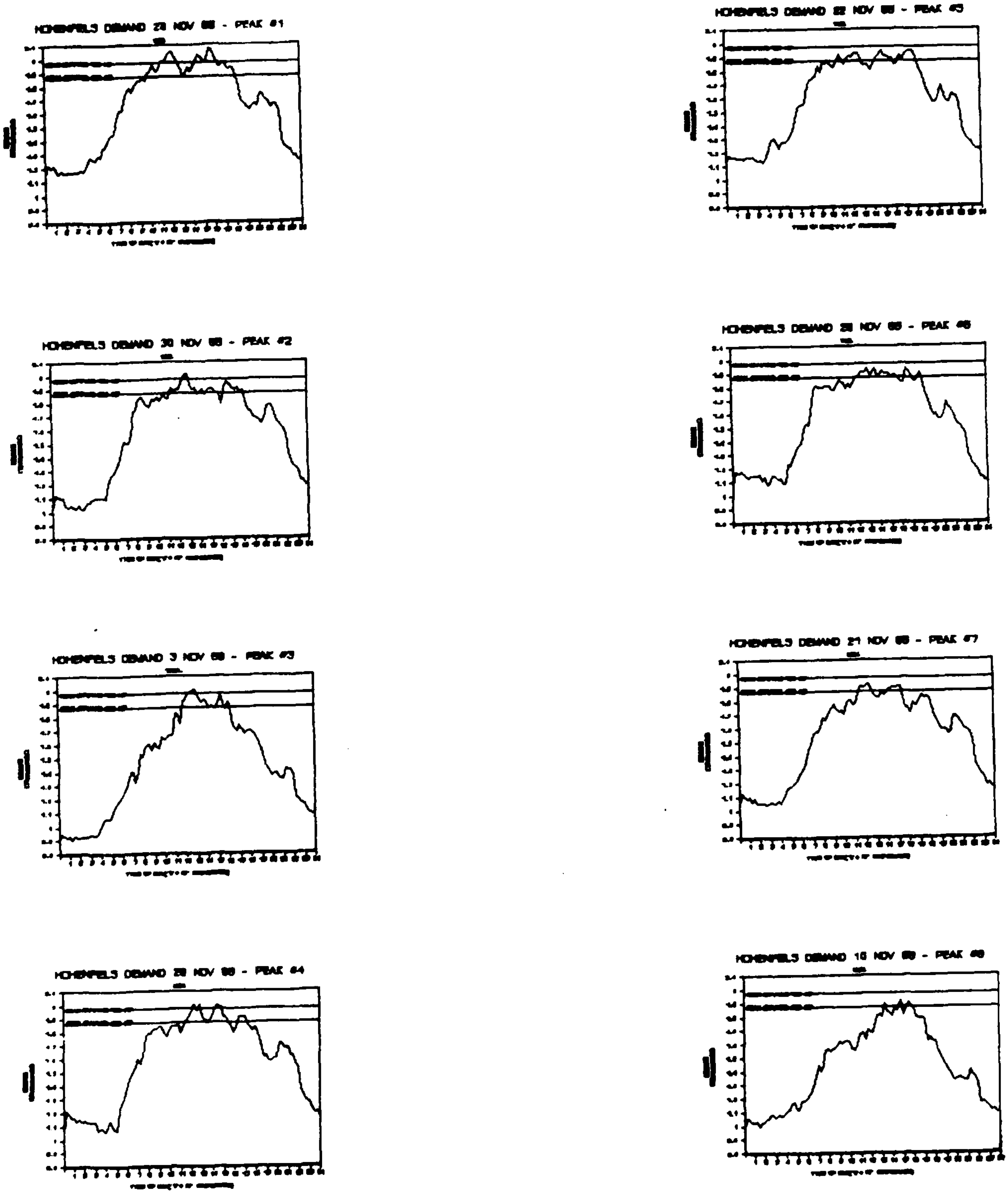


Figure 20. Hohenfels eight highest peak demand days for November 1988.

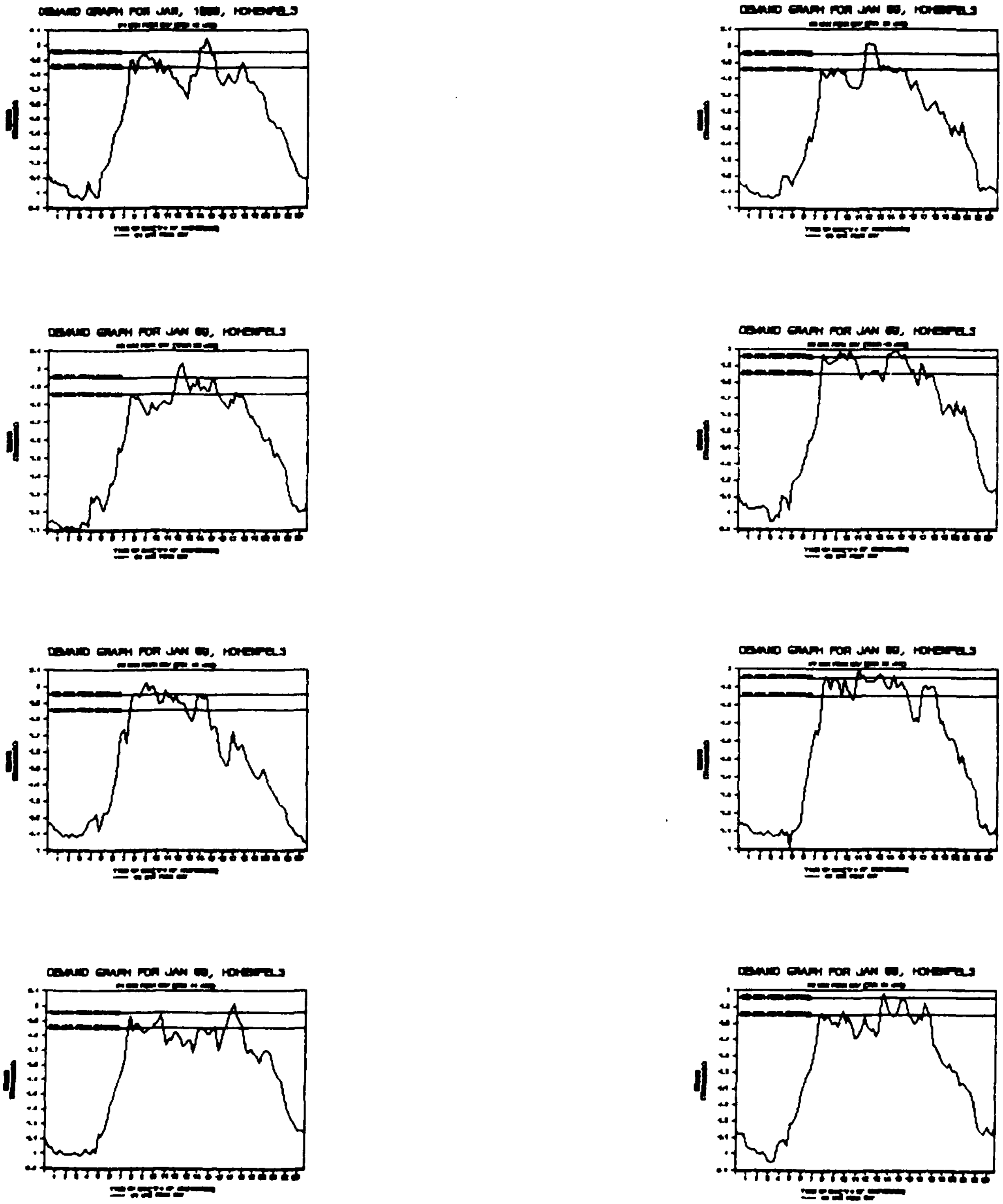


Figure 21. Hohenfels eight highest peak demand days for January 1989.

Table 10

Hohenfels Required 15-Min Intervals of Action for Peak Shaving

Peak Shaving (kW)	No. of Days/Month Affected	No. of 15-Min Intervals/Month Affected
November 88 Data		
20	1	3
40	1	6
60	1	7
80	4	16
100	4	27
120	4	33
140	6	49
160	8	78
January 89 Data		
20	1	1
40	5	6
60	7	13
80	8	25
100	9	42
120	10	80
140	14	106
160	15	149

Figures 24 and 25 indicate that the top six building categories account for more than 50 percent of the installation projected monthly kilowatt-hours. These building categories are:

- Troop dining (20 percent)
- Heating plants (8 percent)
- Exterior lighting (7 percent)
- Installation water supply (7 percent)
- Family housing (6 percent)
- Gym/Recreational buildings (5 percent).

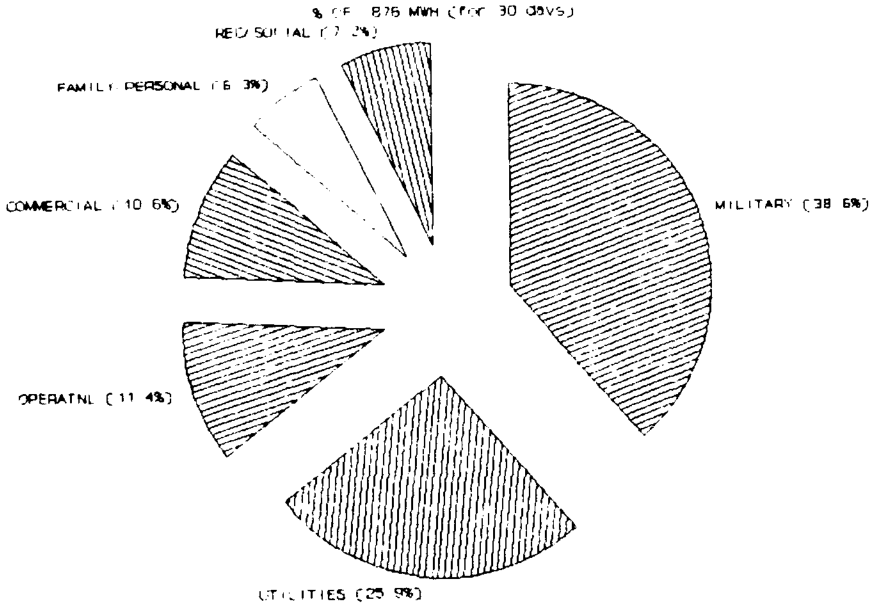


Figure 22. Hohenfels' projected kWh usage by six major functional areas.

Figures 26 and 27 are graphs indicating the load portion of various building categories as part of total lighting load, motor load, mission equipment load, and support equipment load. It is interesting how a relatively few building categories account for a large percentage (50 to 75 percent) of each load type.

Figure 28 shows the projected 24-hr profile and subprofiles for weekdays and weekends at Hohenfels. To calculate the portion of consumption during night baseline compared with daytime peak hours, the profile is dissected as shown in Figure 33.

Area A is defined as the night baseline consumption. Area B is the day baseline and area C is the daytime consumption. By observing the curves in Figure 28, the vertical lines separating areas A and B were chosen at 0630 and 2230 hours.

Table 11 summarizes the calculated area under the profiles (from Figure 28). From the table, weekday projected consumption is 25 percent night baseline, 50 percent daytime baseline, and 25 percent on-peak use.

Figures 29 through 32 show the projected major loads of individual buildings during day and night hours for both weekdays and weekends. Because the data base used for these projections was developed by averaging data from a group of buildings, individual building projections may vary substantially from actual use. These projections are intended mainly for use by persons familiar with the installation. Their purpose is to suggest potential starting locations for identifying energy conservation opportunities. Therefore, the projected consumption numbers for individual buildings should be used with caution.

NO BLDG CATEGORY	% OF TOTAL	KWH	% LIGHTING	% MOTORS	% MISSION	% SUPPORT
MILITARY SUPPORT						
16 I Dining	20.14	178569	11.0	0.1	88.4	0.5
49 Airfld Area	4.45	39467	6.4	0.2	91.1	2.2
12 Hutments	4.06	35960	98.1	0.0	0.0	1.9
44 Wash Fac	4.03	35692	0.0	100.0	0.0	0.0
15 Electron Maint	1.73	15344	20.7	50.1	24.8	4.5
3 Motor/Tank/Repr	1.50	13280	48.5	8.5	34.6	8.4
2 Trning	1.44	12773	56.6	0.3	31.9	11.1
43 Det Lavatory	0.73	6462	36.6	0.0	0.0	63.4
7 Troop Hsing	0.32	2857	34.1	4.7	11.6	49.7
14 Missile Maint	0.20	1778	39.6	0.0	38.0	22.4
21 Trning Aids Ctr	0.00	0	0.0	0.0	0.0	0.0
50 Trning Ranges	0.00	0	0.0	0.0	0.0	0.0
13 Trng Simulator	0.00	0	0.0	0.0	0.0	0.0
	-----	--------	------	------	------	------
SUBTOT	38.6	342182	23	13	61	3
UTILITIES						
11 Heat Plt	7.83	69404	3.4	75.3	20.4	0.9
48 Ext Lting	6.92	61365	100.0	0.0	0.0	0.0
47 Inst Water Sup	6.79	60207	0.0	100.0	0.0	0.0
18 Tele Exch	1.83	16209	18.0	0.0	77.7	4.3
51 Sewage Plt	1.14	10112	5.9	86.1	1.4	6.5
45 Rock Crush Plt	0.73	6465	0.0	100.0	0.0	0.0
23 FE Maint	0.67	5935	15.7	33.8	30.8	19.8
22 POL Pump Sta	0.00	0	0.0	0.0	0.0	0.0
	-----	--------	------	------	------	------
SUBTOT	25.9	229698	30	56	13	1
OPERATIONAL SUPPORT						
4 Storage	4.22	37425	19.1	31.5	19.1	30.3
1 Admin	2.80	24823	37.5	2.6	33.0	26.8
10 Cold Stor	1.48	13147	16.2	68.9	9.3	5.6
40 Misc Shed/Garage/	0.88	7811	13.8	3.2	6.8	76.2
5 Medical	0.76	6728	24.1	10.7	48.5	16.7
28 Lunch Rm	0.76	6713	15.3	0.0	84.4	0.3
19 Fire Sta	0.37	3291	31.1	0.0	7.5	61.3
36 Library	0.11	1008	63.6	4.4	14.6	17.4
41 Post Off	0.01	112	37.5	2.6	33.0	26.8
46 Xmitter	0.00	0	0.0	0.0	0.0	0.0
42 Sentry Sta	0.00	0	0.0	0.0	0.0	0.0
	----	-------	------	------	------	------
SUBTOT	11.4	101060	24	22	26	28
COMMERCIAL SERVICES						
9 Commisry	4.18	37029	6.2	92.7	0.5	0.6
8 Dining/Cafe/	2.26	20043	16.2	0.0	83.5	0.3
31 PX Branch	1.71	15181	53.2	0.0	25.0	21.8
30 PX Pet	1.34	11891	62.7	0.1	23.1	14.6
39 Class VI	0.70	6204	12.3	0.0	65.6	22.0
25 Laundry	0.20	1803	13.7	5.6	62.3	18.4
26 Bank	0.09	825	56.1	3.0	16.1	24.8
20 Service Sta	0.07	602	44.8	51.2	0.7	3.2
	----	-------	------	------	------	------
SUBTOT	10.6	93578	24	37	31	8
FAMILY/PERSONAL SERVICES						
6 Family Hsing	5.62	49838	37.1	14.9	36.2	11.8
17 School	0.33	2919	60.9	0.4	4.9	33.8
29 Child Sup Ctr	0.22	1935	53.3	0.0	1.4	45.4
24 Chapel	0.15	1300	27.5	0.0	5.1	67.4
	----	-------	------	------	------	------
SUBTOT	6.3	55992	39	13	33	15
RECREATIONAL/SOCIAL ACTIVITIES						
35 Gym/Rec	4.72	41882	26.7	60.4	8.4	4.5
27 Bowl Ctr	1.00	8895	25.0	7.8	21.0	46.2
37 Rec ctr/EM Club	0.76	6743	79.3	0.0	5.0	15.7
38 Theater	0.37	3244	42.0	42.2	8.1	7.8
34 Communty ctr	0.16	1410	21.1	0.0	14.0	64.9
33 Club/youth/Scout	0.16	1392	42.2	0.0	0.4	57.4
32 Art/Craft/Skill Dev	0.07	643	37.7	0.0	44.3	18.0
	------	-------	------	------	------	------
SUBTOT	7.2	64209	33	43	10	14
	======	======	=======	=======	=======	======
TOTALS	100.00	886719	27	30	36	8

Figure 23. Hohenfels projected kWh breakout.

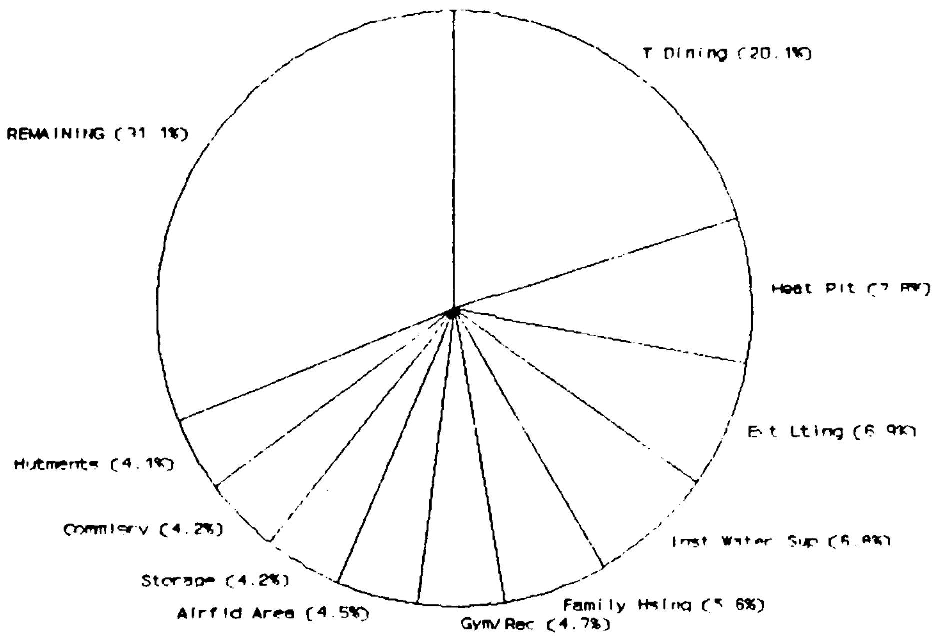
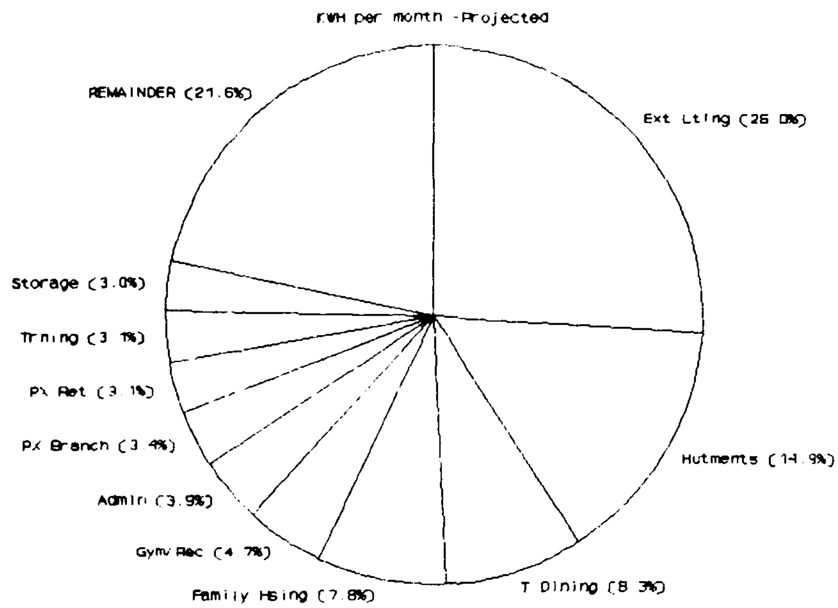


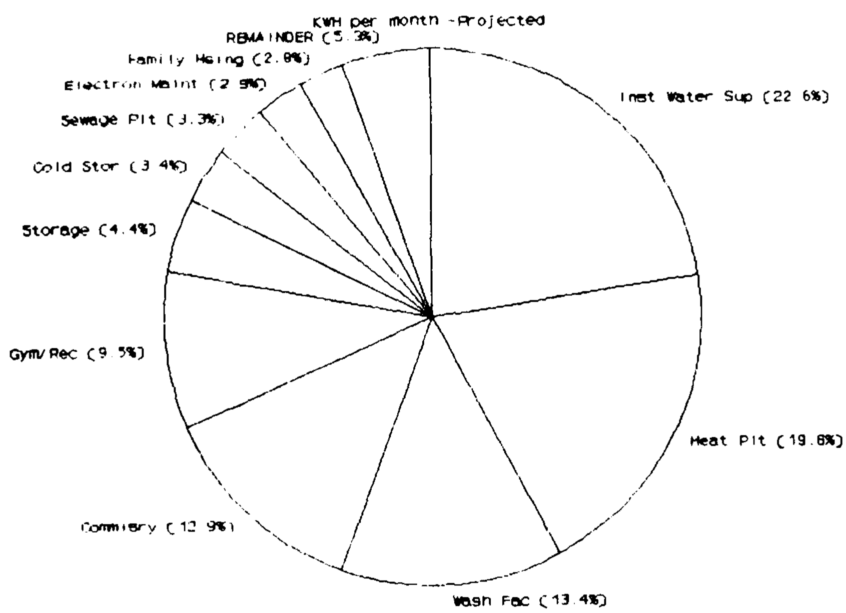
Figure 24. Hohenfels' projected major kWh users by building category.

NO.	BLDG CATEGORY	% OF TOTAL	KWH	% LIGHTING	% MOTORS	% MISSION	% SUPPORT
16	T Dining	20.14	178569	19694	141	157770	964
11	Heat Plt	7.83	69404	2363	52271	14165	604
48	Ext Lting	6.92	61365	61365	0	0	0
47	Inst Water Sup	6.79	60207	0	60207	0	0
6	Family Hsing	5.62	49838	18469	7447	18058	5862
35	Gym/Rec	4.72	41882	11172	25300	3517	1893
49	Airfld Area	4.45	39467	2544	84	35964	874
4	Storage	4.22	37425	7142	11796	7142	11344
9	Commisry	4.18	37029	2284	34309	197	238
12	Hutments	4.06	35960	35272	0	0	688
44	Wash Fac	4.03	35692	0	35692	0	0
1	Admin	2.80	24823	9320	643	8203	6657
8	Dining/Cafe/	2.26	20043	3248	0	16729	66
18	Tele Exch	1.83	16209	2912	0	12601	696
15	Electron Maint	1.73	15344	3172	7685	3803	685
31	PX Branch	1.71	15181	8078	0	3792	3310
3	Motor/Tank/Repr	1.50	13280	6446	112	4599	1110
10	Cold Stor	1.48	13147	2133	9053	1229	732
2	Trning	1.44	12773	7235	41	4079	1418
30	PX Ret	1.34	11891	7397	6	2751	1738
51	Sewage Plt	1.14	10112	601	8710	139	662
27	Bowl Ctr	1.00	8895	2223	692	1868	4111
40	Misc Shed/Garage/	0.88	7811	1079	248	533	5951
37	Rec ctr/EM Club	0.76	6743	5349	0	334	1060
5	Medical	0.76	6728	1621	721	3263	1123
28	Lunch Rm	0.76	6713	1026	0	5668	20
45	Rock Crush Plt	0.73	6465	0	6465	0	0
43	Det Lavatory	0.73	6462	2363	0	0	4099
39	Class VI	0.70	6204	765	0	4072	1367
23	FE Maint	0.67	5935	929	2004	1827	1175
19	Fire Sta	0.37	3291	1025	0	248	2018
38	Theater	0.37	3244	1361	1369	261	252
17	School	0.33	2919	1779	12	142	986
7	Troop Hsing	0.32	2857	973	134	331	1419
29	Child Sup Ctr	0.22	1935	1031	0	26	878
25	Laundry	0.20	1803	247	101	1123	332
14	Missile Maint	0.20	1778	704	0	675	398
34	Commnty ctr	0.16	1410	298	0	198	915
33	Club/youth/Scout	0.16	1392	588	0	5	799
24	Chapel	0.15	1300	358	0	67	876
36	Library	0.11	1008	641	44	147	176
26	Bank	0.09	825	463	25	133	204
32	Art/Craft/Skill Dev	0.07	643	242	0	285	116
20	Service Sta	0.07	602	270	308	4	20
41	Post Off	0.01	112	42	3	37	30
13	Trng Simulator	0.00	0	0	0	0	
46	Xmitter	0.00	0	0	0	0	0
42	Sentry Sta	0.00	0	0	0	0	0
21	Trning Aids Ctr	0.00	0	0	0	0	0
50	Trning Ranges	0.00	0	0	0	0	0
22	POL Pump Sta	0.00	0	0	0	0	0
	TOTALS	******	886719	236,226	266,639	67,867	21,232

Figure 25. Hohenfels building category projected kWh use (sorted by usage).

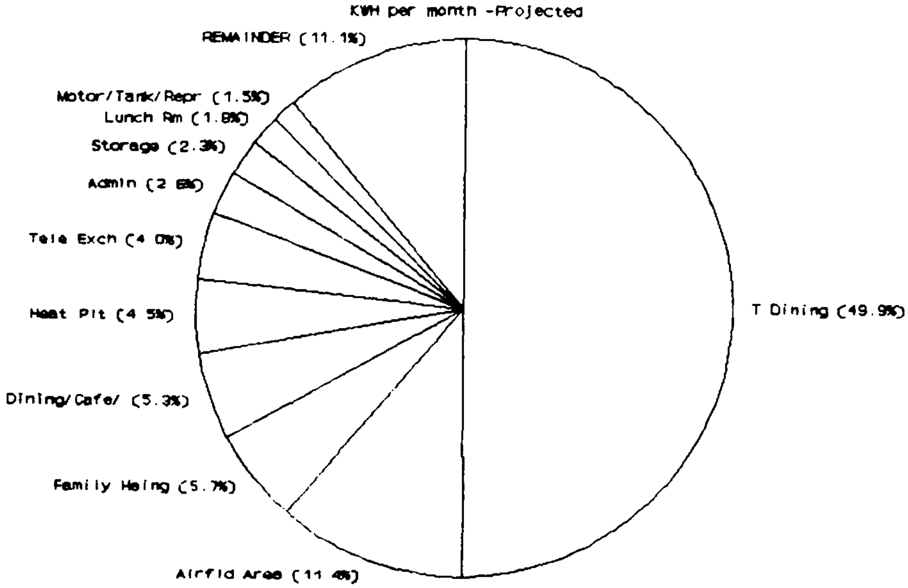


(a)

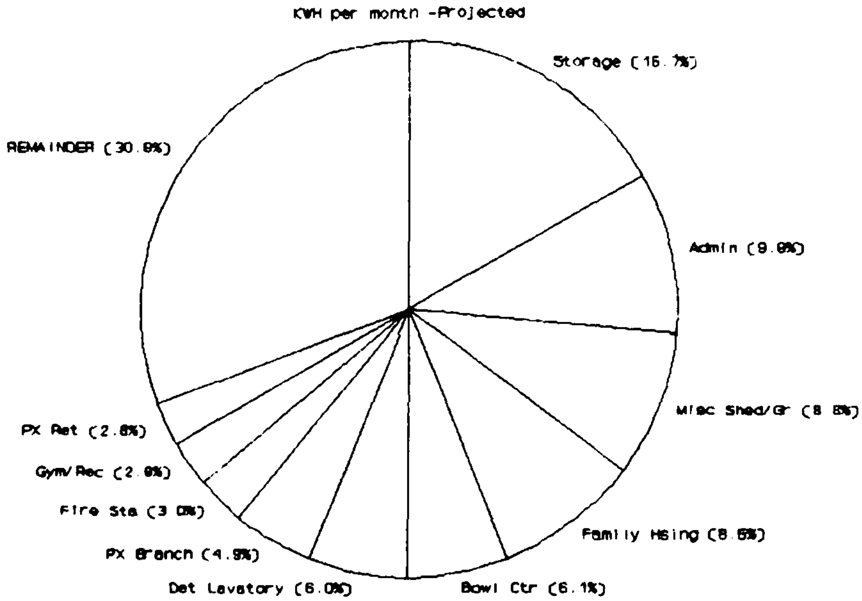


(b)

Figure 26. Hohenfels' projected major: (a) lighting users and (b) motor users by building category.

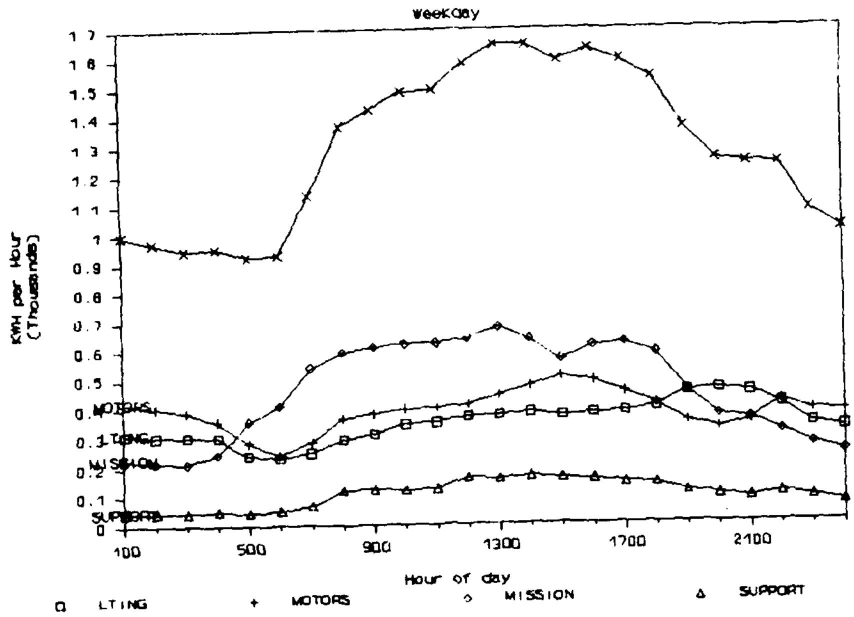


(a)

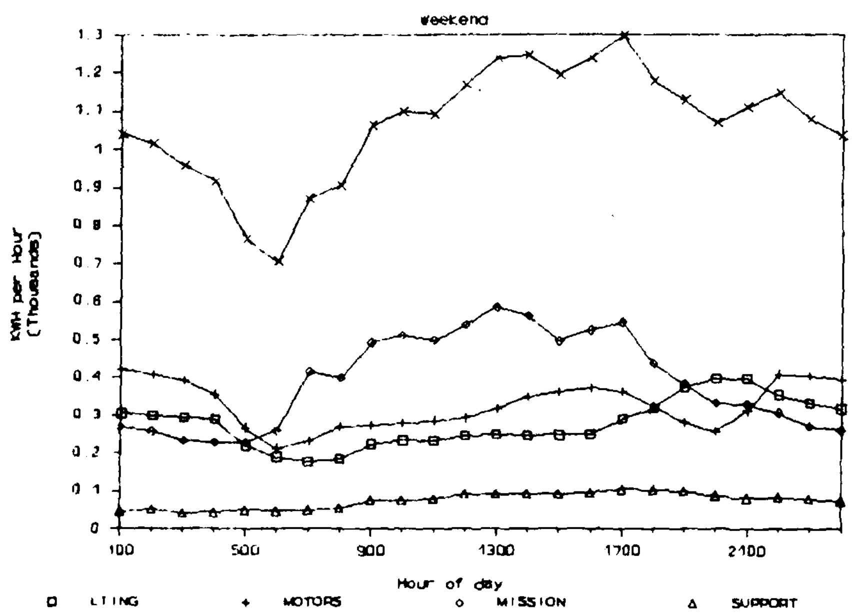


(b)

Figure 27. Hohenfels' projected major: (a) mission equipment users and (b) support equipment users by building category.



(a)



(b)

Figure 28. Hohenfels' projected (a) weekday and (b) weekend profiles and subprofiles.

RANK	BLDG NO.	BLDG DESCRIPTION	BLDG CAT.	BLDG AREA (Sq ft)	LOAD TYPE	5am WkDay KWH/HR
1.	274	HEATING PLANT	11.0	6892	MOTORS	28589
2.	320	HEATING PLANT	11.0	6700	MOTORS	27792
3.	1	commissary	9.0	9000	MOTORS	23383
4.	6	dining facility, off	16.2	15893	MISSION EQ.	15523
5.	10	gen purp warehouse	10.0	24790	MOTORS	12141
6.	3	heating pl coal fir	11.0	2893	MOTORS	12000
7.	24	enl pers dining fac	16.2	12166	MISSION EQ.	11883
8.	702	mnt hangar avum	49.1	4314	MISSION EQ.	11697
9.	88	gymnasium	35.0	22200	MOTORS	9377
10.	3	cafe, coolg units(AD)	8.0	5076	Mission eq.	8795
11.	670	ready bldg	49.1	2860	Mission eq.	7755
12.	274	HEATING PLANT	11.0	6892	Mission eq.	7564
13.	320	HEATING PLANT	11.0	6700	Mission eq.	7353
14.	980	ready bldg	49.1	2691	Mission eq.	7296
15.	54	tele xch building	18.0	4500	Mission eq.	6928
16.	54	tele xch computer ro	18.0	4500	Mission eq.	6928
17.	43	dining facility nco	16.2	6897	Mission eq.	6737
18.	801	enl pers dining fac	16.2	6110	Mission eq.	5968
19.	802	enl pers dining fac	16.2	6110	Mission eq.	5968
20.	803	enl pers dining fac	16.2	6110	Mission eq.	5968
21.	808	enl pers dining fac	16.2	6110	Mission eq.	5968
22.	809	enl pers dining fac	16.2	6110	Mission eq.	5968
23.	810	enl pers dining fac	16.2	6110	Mission eq.	5968
24.	811	enl pers dining fac	16.2	6110	Mission eq.	5968
25.	358	enl pers dining fac	16.2	5404	Mission eq.	5278
26.	51	clinic w/beds	5.0	22203	Mission eq.	5014
27.	47	gymnasium	35.0	10951	MOTORS	4626
28.	154	enl pers dining fac	16.2	4664	Mission eq.	4555
29.	155	enl pers dining fac	16.2	4664	Mission eq.	4555
30.	156	enl pers dining fac	16.2	4664	Mission eq.	4555
31.	157	enl pers dining fac	16.2	4664	Mission eq.	4555
32.	158	enl pers dining fac	16.2	4664	Mission eq.	4555
33.	159	enl pers dining fac	16.2	4664	Mission eq.	4555
34.	162	enl pers dining fac	16.2	4664	Mission eq.	4555
35.	163	enl pers dining fac	16.2	4664	Mission eq.	4555
36.	164	enl pers dining fac	16.2	4664	Mission eq.	4555
37.	165	enl pers dining fac	16.2	4664	Mission eq.	4555
38.	166	enl pers dining fac	16.2	4664	Mission eq.	4555
39.	167	enl pers dining fac	16.2	4664	Mission eq.	4555
40.	181	enl pers dining fac	16.2	4664	Mission eq.	4555
41.	182	enl pers dining fac	16.2	4664	Mission eq.	4555
42.	183	enl pers dining fac	16.2	4664	Mission eq.	4555
43.	184	enl pers dining fac	16.2	4664	Mission eq.	4555
44.	185	enl pers dining fac	16.2	4664	Mission eq.	4555
45.	186	enl pers dining fac	16.2	4664	Mission eq.	4555
46.	259	enl pers dining fac	16.2	4664	Mission eq.	4555
47.	260	enl pers dining fac	16.2	4664	Mission eq.	4555
48.	261	enl pers dining fac	16.2	4664	Mission eq.	4555
49.	262	enl pers dining fac	16.2	4664	Mission eq.	4555
50.	263	enl pers dining fac	16.2	4664	Mission eq.	4555

Figure 29. Hohenfels' greatest projected building loads at 5 a.m. weekdays.

RANK	BLDG NO.	BLDG DESCRIPTION	BLDG CAT.	BLDG AREA (Sq ft)	LOAD TYPE	1pm WkDay KWH/HR
1.	3	cafe, coolg units(AD	8.0	5076	MISSION EQ.	41671
2.	274	HEATING PLANT	11.0	6892	MOTORS	32657
3.	320	HEATING PLANT	11.0	6700	MOTORS	31747
4.	88	gymnasium	35.0	22200	MOTORS	28335
5.	1	commissary	9.0	9000	MOTORS	24453
6.	6	dining facility, off	16.2	15893	MISSION EQ.	23005
7.	3	exch main ret store	30.0	11097	LIGHTING	19177
8.	24	enl pers dining fac	16.2	12166	MISSION EQ.	17610
9.	702	mnt hangar avum	49.1	4314	MISSION EQ.	14950
10.	12	gen purp warehouse	4.0	14826	SUPPORT EQ.	14328
11.	47	gymnasium	35.0	10951	MOTORS	13978
12.	88	gymnasium	35.0	22200	LIGHTING	13898
13.	54	tel exch building	18.0	4500	MISSION EQ.	13757
14.	54	tel exch computer ro	18.0	4500	MISSION EQ.	13757
15.	3	heating pl coal fir	11.0	2893	MOTORS	13708
16.	14	bowling center	27.0	3877	SUPPORT EQ.	13148
17.	10	gen purp warehouse	10.0	24790	MOTORS	11254
18.	43	dining facility nco	16.2	6897	MISSION EQ.	9983
19.	670	ready bldg	49.1	2860	MISSION EQ.	9911
20.	511	elec mnt shop	15.0	16076	MOTORS	9808
21.	168	exch branch	31.0	9872	LIGHTING	9698
22.	274	HEATING PLANT	11.0	6892	MISSION EQ.	9556
23.	980	ready bldg	49.1	2691	MISSION EQ.	9326
24.	320	HEATING PLANT	11.0	6700	MISSION EQ.	9290
25.	808	enl pers dining fac	16.2	6110	MISSION EQ.	8844
26.	810	enl pers dining fac	16.2	6110	MISSION EQ.	8844
27.	803	enl pers dining fac	16.2	6110	MISSION EQ.	8844
28.	811	enl pers dining fac	16.2	6110	MISSION EQ.	8844
29.	801	enl pers dining fac	16.2	6110	MISSION EQ.	8844
30.	809	enl pers dining fac	16.2	6110	MISSION EQ.	8844
31.	802	enl pers dining fac	16.2	6110	MISSION EQ.	8844
32.	511	elec mnt shop	15.0	16076	LIGHTING	8560
33.	40	recreation center	37.0	18386	LIGHTING	8394
34.	3	cafe, coolg units(AD	8.0	5076	LIGHTING	8207
35.	10	gen purp warehouse	10.0	24790	LIGHTING	8169
36.	358	enl pers dining fac	16.2	5404	MISSION EQ.	7822
37.	168	exch branch	31.0	9872	MISSION EQ.	7473
38.	47	gymnasium	35.0	10951	LIGHTING	6856
39.	5	dep grade school	17.0	15500	LIGHTING	6757
40.	267	enl pers dining fac	16.2	4664	MISSION EQ.	6751
41.	368	enl pers dining fac	16.2	4664	MISSION EQ.	6751
42.	181	enl pers dining fac	16.2	4664	MISSION EQ.	6751
43.	183	enl pers dining fac	16.2	4664	MISSION EQ.	6751
44.	167	enl pers dining fac	16.2	4664	MISSION EQ.	6751
45.	185	enl pers dining fac	16.2	4664	MISSION EQ.	6751
46.	181	enl pers dining fac	16.2	4664	MISSION EQ.	6751
47.	186	enl pers dining fac	16.2	4664	MISSION EQ.	6751
48.	260	enl pers dining fac	16.2	4664	MISSION EQ.	6751
49.	259	enl pers dining fac	16.2	4664	MISSION EQ.	6751
50.	262	enl pers dining fac	16.2	4664	MISSION EQ.	6751

Figure 30. Hohenfels' top projected loads at 1 p.m. weekdays.

RANK	BLDG NO.	BLDG DESCRIPTION	BLDG CAT.	BLDG AREA (Sq ft)	LOAD TYPE	6am WkEND KWH/HR
====	=========================	=====	========	===========	=======	
1.	320	HEATING PLANT	11.0	6700	MOTORS	28338
2.	3	cafe, coolg units(AD	8.0	5076	MISSION EQ.	27781
3.	274	HEATING PLANT	11.0	6892	MOTORS	27007
4.	702	mnt hangar avum	49.1	4314	MISSION EQ.	21919
5.	1	commissary	9.0	9000	MOTORS	13598
6.	12	gen purp warehouse	4.0	14826	SUPPORT EQ.	13524
7.	24	enl pers dining fac	16.2	12166	MISSION EQ.	12171
8.	6	dining facility, off	16.2	15893	MISSION EQ.	11661
9.	803	enl pers dining fac	16.2	6110	MISSION EQ.	10812
10.	88	gymnasium	35.0	22200	MOTORS	8485
11.	47	gymnasium	35.0	10951	MOTORS	8069
12.	54	tel exch computer ro	18.0	4500	MISSION EQ.	7592
13.	88	gymnasium	35.0	22200	LIGHTING	7130
14.	54	tel exch building	18.0	4500	MISSION EQ.	6932
15.	14	bowling center	27.0	3877	SUPPORT EQ.	6653
16.	3	heating pl coal fir	11.0	2893	MOTORS	6653
17.	162	enl pers dining fac	16.2	4664	MISSION EQ.	6594
18.	3	exch main ret store	30.0	11097	LIGHTING	6495
19.	164	enl pers dining fac	16.2	4664	MISSION EQ.	4075
20.	10	gen purp warehouse	10.0	24790	MOTORS	3682
21.	163	enl pers dining fac	16.2	4664	MISSION EQ.	3675
22.	810	enl pers dining fac	16.2	6110	MISSION EQ.	3578
23.	182	enl pers dining fac	16.2	4664	MISSION EQ.	3536
24.	261	enl pers dining fac	16.2	4664	MISSION EQ.	3480
25.	155	enl pers dining fac	16.2	4664	MISSION EQ.	3479
26.	156	enl pers dining fac	16.2	4664	MISSION EQ.	3267
27.	274	HEATING PLANT	11.0	6892	MISSION EQ.	3262
28.	511	elec mnt shop	15.0	16076	MOTORS	3262
29.	168	exch branch	31.0	9872	LIGHTING	3262
30.	43	dining facility nco	16.2	6897	MISSION EQ.	3262
31.	320	HEATING PLANT	11.0	6700	MISSION EQ.	3262
32.	980	ready bldg	49.1	2691	MISSION EQ.	3262
33.	670	ready bldg	49.1	2860	MISSION EQ.	3262
34.	154	enl pers dining fac	16.2	4664	MISSION EQ.	2993
35.	392	veh mnt dir sup	3.0	17834	LIGHTING	2958
36.	269	enl pers dining fac	16.2	4664	MISSION EQ.	2954
37.	159	enl pers dining fac	16.2	4664	MISSION EQ.	2912
38.	808	enl pers dining fac	16.2	6110	MISSION EQ.	2885
39.	158	enl pers dining fac	16.2	4664	MISSION EQ.	2717
40.	34	fe storehouse	4.0	6770	SUPPORT EQ.	2638
41.	29	fe storehouse	4.0	6945	SUPPORT EQ.	2560
42.	260	enl pers dining fac	16.2	4664	MISSION EQ.	2490
43.	330	enl pers dining fac	16.2	4664	MISSION EQ.	2490
44.	181	enl pers dining fac	16.2	4664	MISSION EQ.	2490
45.	167	enl pers dining fac	16.2	4664	MISSION EQ.	2490
46.	368	enl pers dining fac	16.2	4664	MISSION EQ.	2490
47.	181	enl pers dining fac	16.2	4664	MISSION EQ.	2490
48.	267	enl pers dining fac	16.2	4664	MISSION EQ.	2490
49.	811	enl pers dining fac	16.2	6110	MISSION EQ.	2490
50.	[illegible]	dep grade school	17.0	15500	LIGHTING	2490

Figure 31. Hohenfels' top projected loads at 6 a.m. weekends.

RANK	BLDG NO.	BLDG DESCRIPTION	BLDG CAT.	BLDG AREA (Sq ft)	LOAD TYPE	5pm WkEND KWH/HR
1.	803	enl pers dining fac	16	6110	MISSION EQ.	30677
2.	320	HEATING PLANT	11	6700	MOTORS	27737
3.	88	gymnasium	35	22200	MOTORS	27388
4.	3	cafe, coolg units(AD	8	5076	MISSION EQ.	26964
5.	274	HEATING PLANT	11	6892	MOTORS	23541
6.	702	mnt hangar avum	49	4314	MISSION EQ.	19699
7.	802	enl pers dining fac	16	6110	MISSION EQ.	18604
8.	388	storage room	4	6110	SUPPORT EQ.	17482
9.	157	enl pers dining fac	16	4664	MISSION EQ.	15568
10.	274	HEATING PLANT	11	6892	MISSION EQ.	15132
11.	24	enl pers dining fac	16	12166	MISSION EQ.	15079
12.	6	dining facility, off	16	15893	MISSION EQ.	12926
13.	183	enl pers dining fac	16	4664	MISSION EQ.	12841
14.	12	gen purp warehouse	4	14826	SUPPORT EQ.	11643
15.	42	aces facility	2	6413	LIGHTING	10930
16.	328	enl pers dining fac	16	4664	MISSION EQ.	10745
17.	1	commissary	9	9000	MOTORS	10424
18.	265	enl pers dining fac	16	4664	MISSION EQ.	10111
19.	8	fam hsg fgn enl	6	42621	LIGHTING	10078
20.	14	bowling center	27	3877	MISSION EQ.	9685
21.	160	exch serv outlet(PX,	31	4664	MISSION EQ.	9261
22.	807	elec mnt shop	15	4664	MOTORS	8624
23.	47	gymnasium	35	10951	MOTORS	8569
24.	162	enl pers dining fac	16	4664	MISSION EQ.	8549
25.	54	tel exch building	18	4500	MISSION EQ.	8063
26.	14	bowling center	27	3877	SUPPORT EQ.	7597
27.	3	heating pl coal fir	11	2893	MOTORS	7597
28.	810	enl pers dining fac	16	6110	MISSION EQ.	7573
29.	161	enl pers dining fac	16	4664	MISSION EQ.	7573
30.	261	enl pers dining fac	16	4664	MISSION EQ.	7573
31.	3	exch main ret store	30	11097	LIGHTING	7573
32.	182	enl pers dining fac	16	4664	MISSION EQ.	7573
33.	163	enl pers dining fac	16	4664	MISSION EQ.	7573
34.	10	gen purp warehouse	10	24790	MOTORS	7573
35.	70	commissary warehouse	4	6110	SUPPORT EQ.	7544
36.	52	storage shed	40	2072	SUPPORT EQ.	7205
37.	54	tel exch computer ro	18	4500	MISSION EQ.	7130
38.	753	fe store house	4	119	LIGHTING	7046
39.	385	gen instr bldg	2	3328	LIGHTING	6968
40.	169	clothg sales st/barb	30	3328	LIGHTING	6956
41.	88	gymnasium	35	22200	LIGHTING	6932
42.	155	enl pers dining fac	16	4664	MISSION EQ.	6698
43.	3	cafe, coolg units(AD	8	5076	LIGHTING	6594
44.	84	fe storehouse	4	361	MOTORS	6541
45.	3	exch main ret store	30	11097	MISSION EQ.	6538
46.	[illegible]	storage shed	40	363	LIGHTING	6510
47.	1	class VI store	39	3100	MISSION EQ.	6392
48.	[illegible]	enl pers dining fac	16	4664	MISSION EQ.	5781
49.	181	enl pers dining fac	16	4664	MISSION EQ.	5781
50.	13	dining facility nco	16	6897	MISSION EQ.	5781

Figure 32. Hohenfels' top projected loads at 5 p.m. weekends.

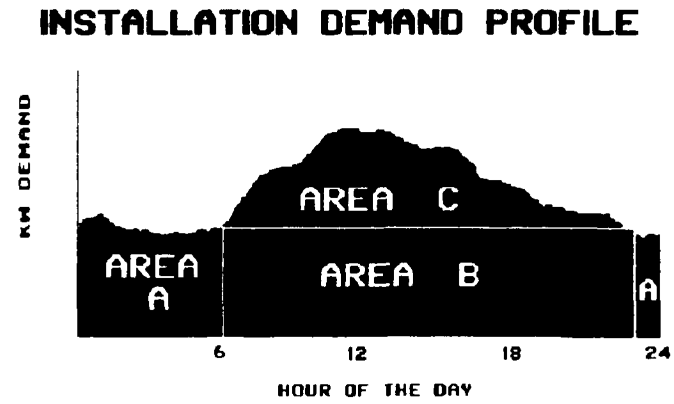


Figure 33. Dissection of profile into baseline and peak areas.

Table 11

Hohenfels Usage: Night Baseline vs. Day Baseline vs. Day Peak

Projected Baseline vs. Peak kWh Consumption			
	kWh/Day Sum	Avg	% of Total
Weekday			
Night baseline (2300-0600)	7808	976	25.2
Day baseline (0700-2200)	15616		50.4
Day on-peak (0700-2200)	7587		24.5
	23203		74.8
Total	31011		100.0
Weekend			
Night baseline (2300-0600)	7513	939	29.4
Day baseline (0700-2200)	0		0.0
Day on-peak (0700-2200)	18047		70.6
	18047		70.6
Total	25561		100.0

6 EVALUATION OF ELECTRICAL CONSUMPTION AT GRAFENWÖHR

Grafenwöhr Historical Monthly Kilowatt-Hour Consumption

Table 12 lists monthly electrical utility billing information for the Grafenwöhr cantonment area main meter from 1981 through 1988. Figure 34 shows Grafenwöhr's annual kilowatt-hour usage for 1981 through 1988. Note that, over the 7 years, annual kilowatt-hour use has grown 58 percent (average 8.3 percent per year). Figure 35 shows monthly kilowatt-hour use for several years. From the graph, consumption trends are not obvious. However, when each monthly reading is averaged with the same month's readings from other years (shown in Figure 36), a trend can be seen. Figure 36 indicates a higher winter kilowatt-hour consumption during October through March, a transition to lower consumption in April, and a lowered summer consumption during May through September. This trend is not surprising in light of the relatively low summer air-conditioning load and the greater winter loads due to heating requirements, increased use of lighting to offset the reduced winter daylight, and some supplemental electric space heating (unauthorized, in some cases). Total cost for electricity (including demand charges) for 1987 was 3.5 million DMarks (about $1.8 million @ 1.9 DM/$).

Grafenwöhr Monthly Peak Demand

The utility billing data in Table 12 indicate the peak kilowatt demand at Grafenwöhr for each month. As is common in electricity rate structures, the customer must pay not only for the energy (kWh) used but, also, for the peak load (kW) during specified time intervals. The peak demand numbers indicate the highest average demand (kW) during any 15-min interval of the month. To compute the annual demand charge, the peak demand numbers from the highest 2 months are averaged together. This 2-month average is multiplied by the demand charge rate (currently 232.8 DMarks/kW) to arrive at the annual demand charge. Although the highest 2 months cannot be known until the final month of the calendar year (and therefore the exact charge cannot be computed monthly during the year), some reasonable portion of the expected annual demand charge is paid each month and contributes to the final charge to be assessed at the end of December each year. Actual demand charges for several past years are also shown in Table 12. For the years shown, demand charges constituted 27 percent (average) of the total cost of electricity.

Since demand charges are a significant portion of total electricity costs, a closer examination of demand trends is needed. Figure 37 graphs the monthly peak demand at Grafenwöhr for 1983 through 1988. One question of interest is whether the two highest demand months occur repeatedly at the same month each year. For the 14 "high" months in the 7 years of data, December and January each yielded three peak months. October, February, and March each yielded two peak months. All but one of the peak months occurred in the October to March winter season. The one exception was in June.

Also of interest is the extremity of the peak months compared with other months. A lack of extremity would mean that major peak shaving actions during peak months may leave other months as peaks, requiring peak shaving actions in additional months. In 2 years (1988 and 1981), the top 3 months were separated from the fourth highest month by more than 160 kW. In 1986, the top 2 months were more than 380 kW higher than the third highest month. In the remaining 4 years of observed data, the difference between adjacent months for the second, third, and fourth highest months was less than 85 kW. Therefore, reducing the average of the two peak months by more than 100 kW, for example, would require action during numerous months in some years. In other years, a 100+ kW peak shaving action would only be required in the two or three highest months. Note that a 100-kW reduction in the average of the two peak months would result in annual cost savings of 23,280 DMarks at the current rate of 232.8 DMarks/kW annual peak (2-month average).

Table 12

Grafenwöhr Electricity Use Data 1981-88

YEAR	MONTH	PEAK KW	TOTAL KWH	YEAR	MONTH	PEAK KW	TOTAL KWH
1981	JAN	2810	1386660				
1981	FEB	2850	1379940				
1981	MAR	2850	1464060				
1981	APR	2640	1379940				
1981	MAY	2630	1106700	1985 DATA NOT OBTAINED			
1981	JUN	2380	1106700				
1981	JUL	2760	1345200				
1981	AUG	2530	1192860				
1981	SEP	2460	1069880				
1981	OCT	3190	1566540				
1981	NOV	3010	1465980				
1981	DEC	3230	1556040				
1982	JAN	3180	1506360	1986	JAN	4559.3	2413300
1982	FEB	3380	1606440	1986	FEB	4468.2	2279665
1982	MAR	3250	1745520	1986	MAR	3890.0	2011717
1982	APR	3130	1716060	1986	APR	3692.7	2000979
1982	MAY	3230	1444200	1986	MAY	3294.9	1798612
1982	JUN	2930	1400760	1986	JUN	3566.0	1647515
1982	JUL	2710	1408920	1986	JUL	3371.0	1730044
1982	AUG	2690	1279860	1986	AUG	3455.6	1238112
1982	SEP	2740	1322880	1986	SEP	3644.1	1827435
1982	OCT	3170	1631580	1986	OCT	3557.7	1965000
1982	NOV	3140	1540500	1986	NOV	4087.2	2010713
1982	DEC	3020	1545600	1986	DEC	4025.6	2087029
1983	JAN	3420	1724100	1987	JAN	4267.4	2247136
1983	FEB	3440	1716180	1987	FEB	4116.3	2105275
1983	MAR	3410	1948380	1987	MAR	4217.6	2381805
1983	APR	3270	1376820	1987	APR	4145.0	2181231
1983	MAY	3340	1584820	1987	MAY	3626.8	1658843
1983	JUN	3100	1439200	1987	JUN	3358.9	1616006
1983	JUL	2820	1454560	1987	JUL	3268.9	1808661
1983	AUG	2960	1445120	1987	AUG	3800.0	1709336
1983	SEP	3020	1557680	1987	SEP	3885.5	1781913
1983	OCT	3520	1748720	1987	OCT	3683.9	2021277
1983	NOV	3600	1709705	1987	NOV	4064.1	2120146
1983	DEC	3294.6	1701741	1987	DEC	4302.3	2329293
1984	JAN	3501.4	1882289	1988	JAN	4299.2	2155187
1984	FEB	3478.0	1866347	1988	FEB	4265.3	2232720
1984	MAR	3351.4	1913172	1988	MAR	4560.0	2676200
1984	APR	3469.1	1785719	1988	APR	3890.0	1825195
1984	MAY	3460.5	1674403	1988	MAY	3812.1	1885430
1984	JUN	3580.0	1672831	1988	JUN	3834.0	1869155
1984	JUL	3480.0	1518880	1988	JUL	3684.8	1894670
1984	AUG	2840.0	1521358	1988	AUG	3743.2	1939660
1984	SEP	3440.0	1496665	1988	SEP	3857.9	2000675
1984	OCT	2827.6	1849903	1988	OCT	4026.0	2113920
1984	NOV	3368.8	1787258	1988	NOV	4540.9	2393870
1984	DEC	3112.7	1512137	1988	DEC	4665.6	2369507

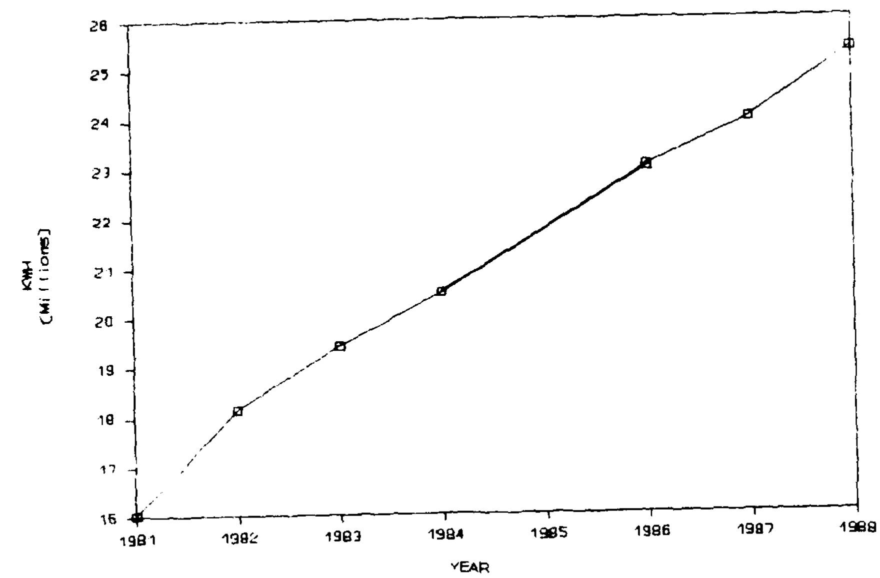


Figure 34. Grafenwöhr annual electricity usage, 1981-88.

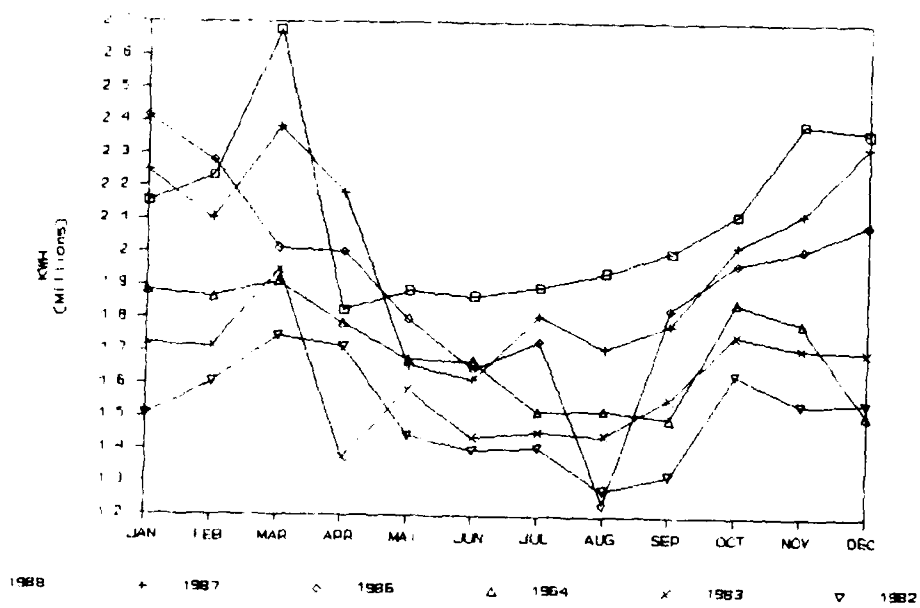


Figure 35. Grafenwöhr monthly kWh electricity usage, 1982-88.

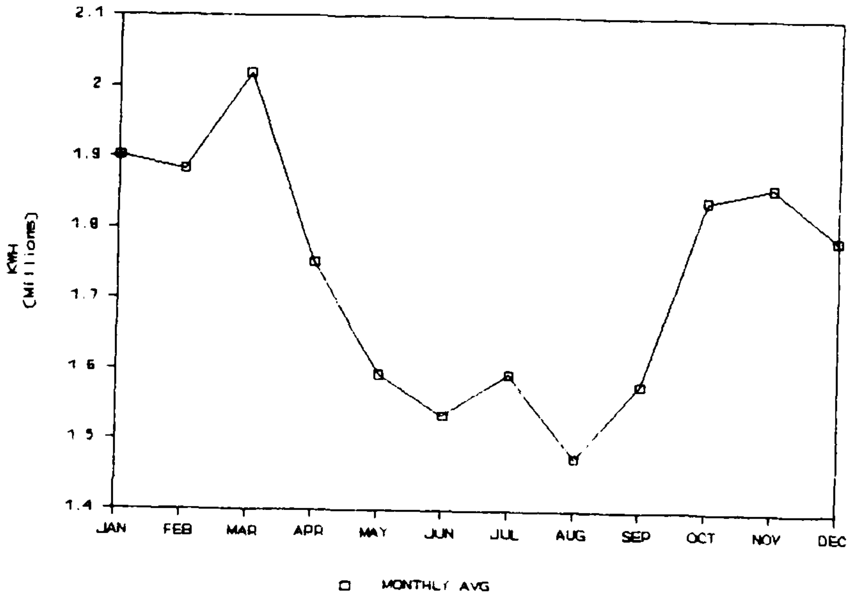


Figure 36. Grafenwöhr average monthly kWh usage, 1981-88 data for each month.

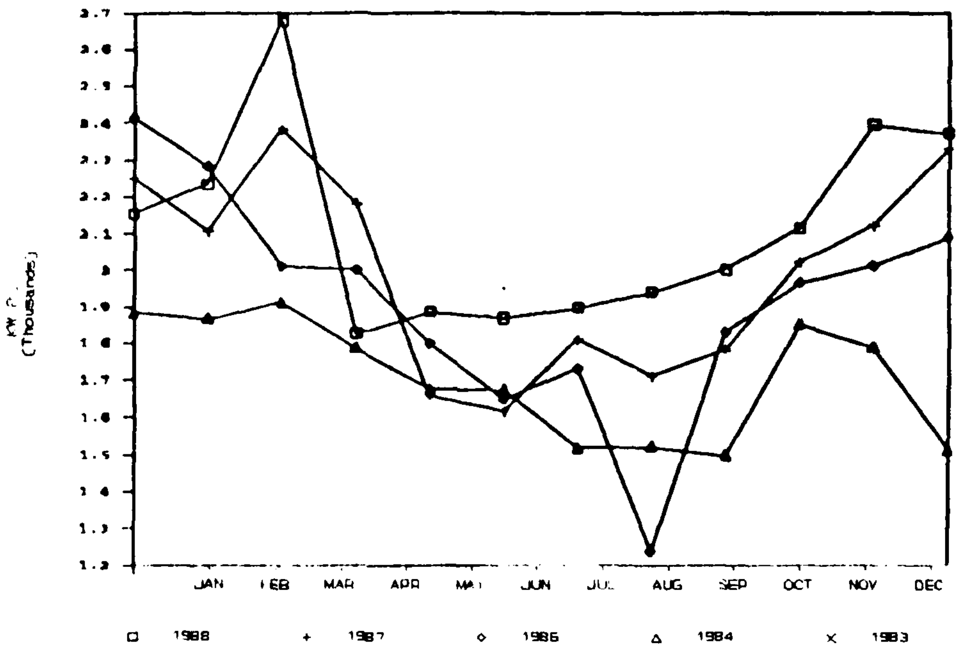


Figure 37. Grafenwöhr monthly peak kW demand for 1983-88.

Grafenwöhr Daily Peak Demand

The monthly peak demand numbers (discussed in the previous paragraph) are the maximum values taken from daily peaks occurring within each month. Just as attempts to reduce monthly peaks are affected by the extremity between months, attempts to reduce the daily peaks are affected by the day-to-day extremity of the peaks.

Data indicating the Grafenwöhr demand for each 15-min interval were obtained for two calendar months--November 1988 and January 1989. Figures 38 and 39 show the daily demand curves for the successive eight highest peaks during November 1988 and January 1989, respectively. Also shown on the graphs are three horizontal lines indicating levels 100 kW, 200 kW, and 300 kW below the *monthly* peak demand. The graphs provide a visual indication of the peak shaving requirement for various reduction levels. For example, at the 200-kW level (below the monthly peak), four January days require peak shaving action (as indicated by peak curves 1 through 3). The peak day 4 curve is more than 200 kW below the monthly peak with no peak shaving action. In November, seven of the eight peak curves require some peak shaving to stay below the 200-kW level. From the same data that produced the graphs above for November 1988 and December 1989, Table 13 summarizes the number of days requiring peak shaving actions and the corresponding number of 15-min intervals for various peak shaving levels.

The flatness of the demand curve is important when considering potential loads to shed. For example, looking at the November peak day 1 curve, further load shedding below the 300-kW line would require a load that can be shed continuously from about 0700 to 1900 hours. Thus, load shedding in this region of the curve necessitates finding loads that can essentially be changed from day to night operating hours. This type of load differs from those that can be controlled for short time intervals to reduce the small spikes along the top of the demand curve. The availability of these various load types will need to be considered when selecting a goal for the amount of peak shaving.

Consumption Projection Program Output

Another way to examine Grafenwöhr's electrical use is to use the data base of "typical" building consumption described in Chapter 2. A variety of usage "breakouts" is possible. A set of outputs (which are currently being programmed as standard format outputs in the PC-based program) are shown in Figures 40 through 50.

Figures 40 and 41 indicate that 41 percent of Grafenwöhr's projected monthly consumption is for military functions, with troop dining facilities (14 percent) and training ranges (11 percent) comprising more than half of the military usage. Within Troop Dining, most of the consumption (88 percent) is for mission-related equipment (i.e., food preparation/serving equipment). The other major military functions (consuming 3 to 4 percent each) are Detached Lavatories, Hutments, Motor/Tank Repair shops, and the Airfield Area.

For Utilities, projected monthly consumption is 18 percent of the installation total. The major utility consumers are Exterior Lighting and the Installation Water Supply System, with each consuming about 7 percent of the installation monthly consumption.

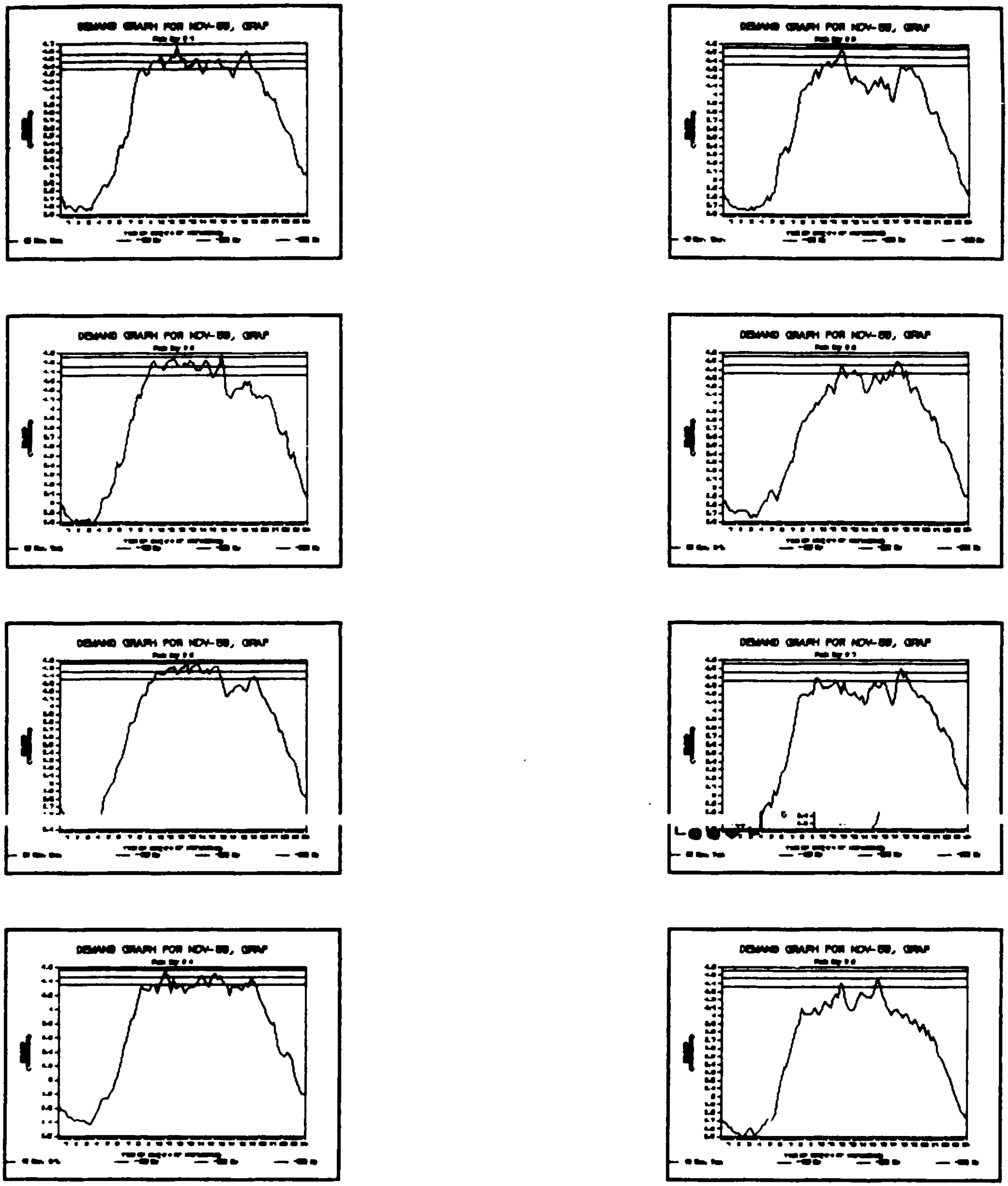


Figure 38. Grafenwöhr's eight highest peak demand days for November 1988.

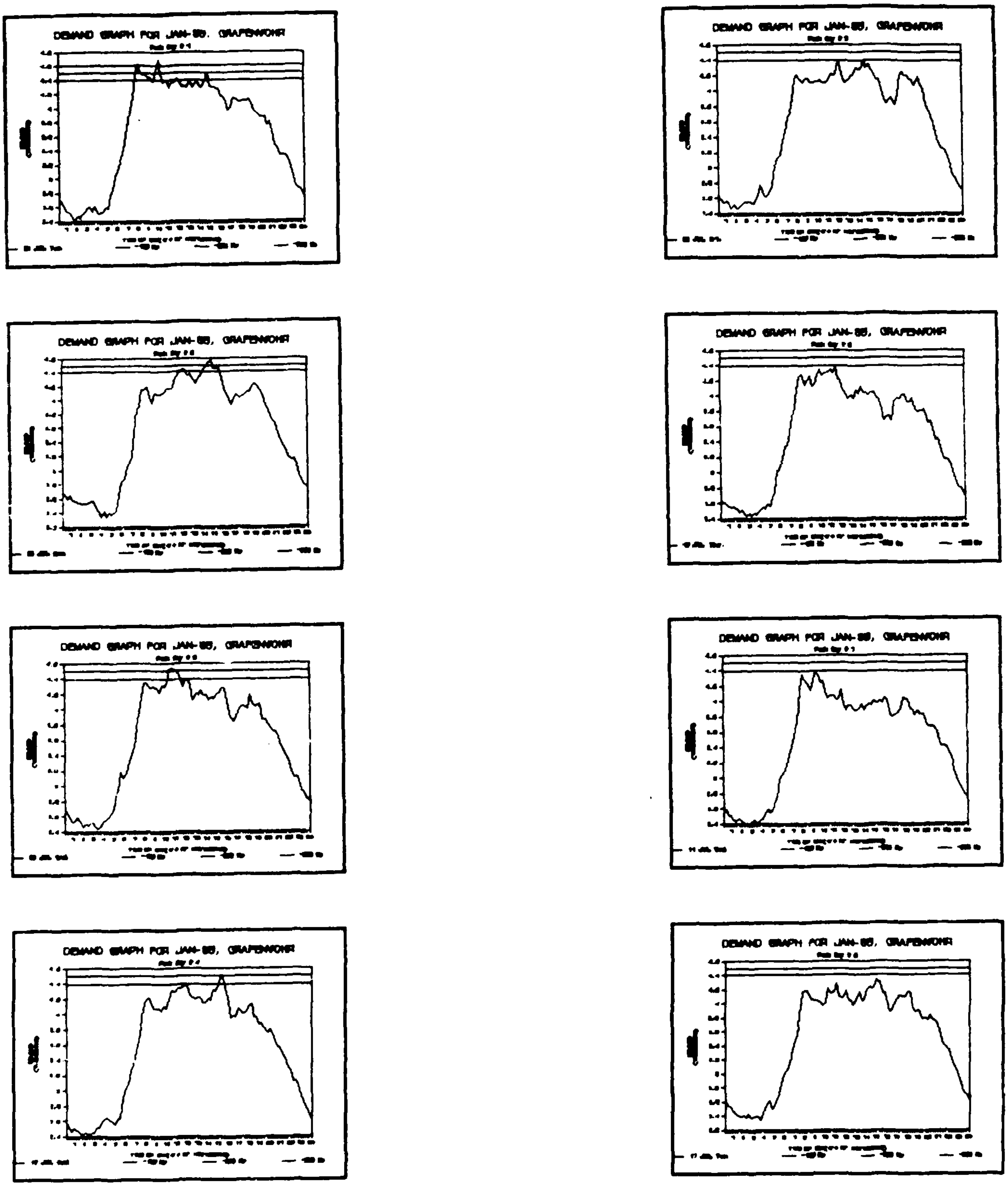


Figure 39. Grafenwöhr's eight highest peak demand days for January 1989.

Table 13

Grafenwöhr Required 15-Min Intervals of Action for Peak Shaving

Peak Shaving (kW)	No. of Days/Months Affected	No. of 15-Min Intervals/Month Affected
November 88 Data		
20	1	2
40	1	2
60	1	2
80	2	5
100	2	7
120	3	11
140	3	15
160	3	25
January 89 Data		
20	1	1
40	1	1
60	1	1
80	1	2
100	1	2
120	1	2
140	2	3
160	3	5

Other building categories consuming at least 2 percent of the installation projected monthly consumption are Storage (4 percent), Administration (2.9 percent), Dining/Cafe/Snack Bar (7.9 percent), the Commissary (2.4 percent), Family Housing (9.6 percent), Gym/Recreational (3.5 percent), and the Bowling Center (2.8 percent).

Figures 42 and 43 indicate that the top five building categories account for some 50 percent of the installation projected monthly kilowatt-hours. These building categories are:

- Troop dining (20 percent)
- Training ranges (11 percent)
- Family housing (10 percent)
- Dining/cafe/snack (8 percent)
- Exterior lighting (7 percent).

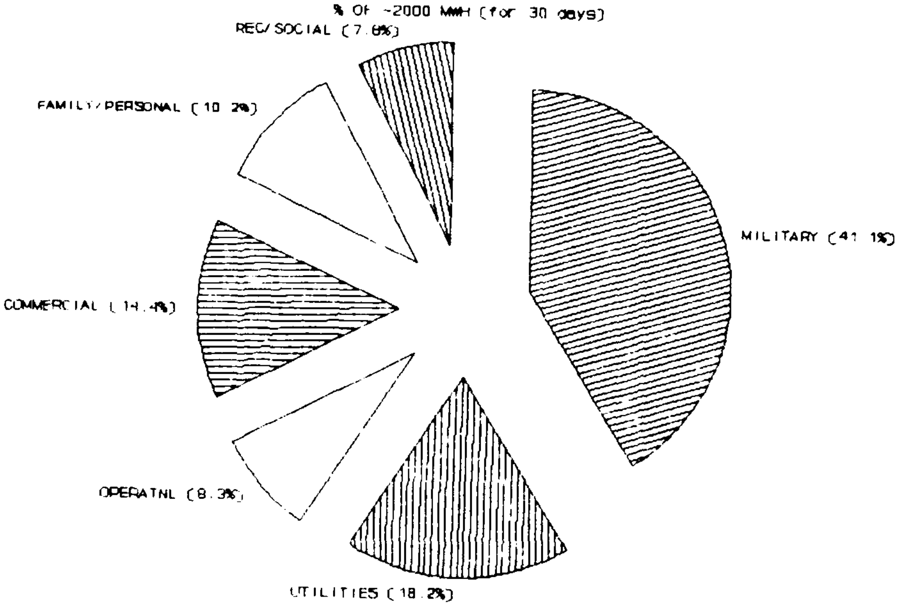


Figure 40. Grafenwöhr's projected kWh usage by six major functional areas.

Figures 44 and 45 are graphs indicating the load portion of various building categories as part of total lighting load, motor load, mission equipment load, and support equipment load. It is interesting how a relatively few building categories account for a large percentage (50 to 75 percent) of each load type.

Figure 46 shows the projected 24-hr profile and subprofiles for weekdays and weekends at Grafenwöhr. To calculate the portion of consumption during night baseline compared with daytime peak hours, the profile is dissected as shown in Figure 51.

Area A in Figure 51 is defined as the night baseline consumption. Area B is the day baseline and area C is the daytime consumption. By observing the curves in Figure 46, the vertical lines separating areas A and B were chosen at 0630 and 2330 hours.

Table 14 summarizes the calculated area under the profiles (from Figure 46). From the table, weekday projected consumption is 23 percent night baseline, 56 percent daytime baseline, and 21 percent on-peak use. Total baseline consumption (79 percent) is clearly an important part of electrical consumption.

Figures 47 through 50 show the projected major loads of individual buildings during day and night hours for both weekdays and weekends. Because the data base used for projections was developed by averaging data from a group of buildings, individual building projections may vary substantially from actual use. These projections are intended mainly for use by persons familiar enough with the building functions to detect unexplainably high projections. Their purpose is to suggest potential starting locations for identifying energy conservation opportunities. Therefore, the projected consumption numbers for individual buildings should be used with caution.

NO.	BLDG CATEGORY	% OF TOTAL	PROJ. KWH (monthly)	% LIGHTING	% MOTORS	% MISSION	% SUPPORT
MILITARY SUPPORT							
16	T Dining	14.05	278429	11.0	0.1	88.4	0.5
50	Trning Ranges	11.37	225257	0.0	0.0	100.0	0.0
43	Det Lavatory	4.29	85013	36.6	0.0	0.0	63.4
12	Hutments	3.43	68036	98.1	0.0	0.0	1.9
3	Motor/Tank/Repr	3.30	65283	48.5	8.5	34.6	8.4
49	Airfld Area	3.20	63474	6.4	0.2	91.1	2.2
7	Troop Hsing	0.50	9876	34.1	4.7	11.6	49.7
13	Trng Simulator	0.30	5850	9.3	1.7	87.5	1.5
2	Trning	0.26	5206	56.6	0.3	31.9	11.1
14	Missile Maint	0.26	5118	39.6	0.0	38.0	22.4
21	Trning Aids Ctr	0.18	3543	60.3	0.0	6.5	33.2
15	Electron Maint	0.00	0	0.0	0.0	0.0	0.0
44	Wash Fac	0.00	0	0.0	0.0	0.0	0.0
	SUBTOTAL	41.1	815086	22	1	69	9
UTILITIES							
48	Ext Lting	6.71	132972	100.0	0.0	0.0	0.0
47	Inst Water Sup	6.59	130465	0.0	100.0	0.0	0.0
11	Heat Plt	2.55	50448	3.4	75.3	20.4	0.9
23	FE Maint	1.49	29493	15.7	33.8	30.8	19.8
18	Tele Exch	0.70	13953	18.0	0.0	77.7	4.3
22	POL Pump Sta	0.14	2736	0.0	100.0	0.0	0.0
45	Rock Crush Plt	0.00	0	0.0	0.0	0.0	0.0
51	Sewage Plt	0.00	0	0.0	0.0	0.0	0.0
	SUBTOTAL	18.2	360066	39	50	8	2
OPERATIONAL SUPPORT							
4	Storage	3.96	78442	19.1	31.5	19.1	30.3
1	Admin	2.87	56794	37.5	2.6	33.0	26.8
40	Misc Shed/Garage	0.52	10259	13.8	3.2	6.8	76.2
19	Fire Sta	0.35	7011	31.1	0.0	7.5	61.3
5	Medical	0.35	6856	24.1	10.7	48.5	16.7
28	Lunch Rm	0.11	2253	15.3	0.0	84.4	0.3
36	Library	0.08	1620	63.6	4.4	14.6	17.4
42	Sentry Sta	0.06	1282	12.5	0.0	1.3	86.2
41	Post Off	0.02	443	37.5	2.6	33.0	26.8
46	Xmitter	0.00	0	0.0	0.0	0.0	0.0
10	Cold Stor	0.00	0	0.0	0.0	0.0	0.0
	SUBTOTAL	8.3	164959	26	17	25	33
COMMERCIAL SERVICES							
8	Dining/Cafe/	7.88	156141	16.2	0.0	83.5	0.3
9	Commisry	2.42	48006	6.2	92.7	0.5	0.6
30	PX Ret	2.19	43360	62.2	0.1	23.1	14.6
31	PX Branch	0.96	19006	53.2	0.0	25.0	21.8
25	Laundry	0.60	11879	13.7	5.6	62.3	18.4
39	Class VI	0.19	3837	12.3	0.0	65.6	22.0
20	Service Sta	0.08	1654	44.8	51.2	0.7	3.2
26	Bank	0.04	815	56.1	3.0	16.1	24.8
	SUBTOTAL	14.4	284698	24	16	55	5
FAMILY/PERSONAL SERVICES							
6	Family Hsing	9.58	189863	37.1	14.9	36.2	11.8
17	School	0.46	9110	60.9	0.4	4.9	33.8
24	Chapel	0.17	3390	27.5	0.0	5.1	67.4
29	Child Sup Ctr	0.00	0	0.0	0.0	0.0	0.0
	SUBTOTAL	10.2	202363	38	14	34	14
RECREATIONAL/SOCIAL ACTIVITIES							
35	Gym/Rec	3.45	68337	26.7	60.4	8.4	4.5
27	Bowl Ctr	2.79	55180	25.0	7.8	21.0	46.2
37	Rec ctr/EM Club	0.65	12906	79.3	0.0	5.0	15.7
38	Theater	0.55	10929	42.0	42.2	8.1	7.8
33	Club/youth/Scout	0.32	6419	42.2	0.0	0.4	57.4
32	Art/Craft/Skill	0.01	182	37.7	0.0	44.3	18.0
34	Commnty ctr	0.00	0	0.0	0.0	0.0	0.0
	SUBTOTAL	7.8	153953	32	33	12	23
	TOTALS	100.00	1981125	28	17	44	11

Figure 41. Grafenwöhr's projected kWh breakout.

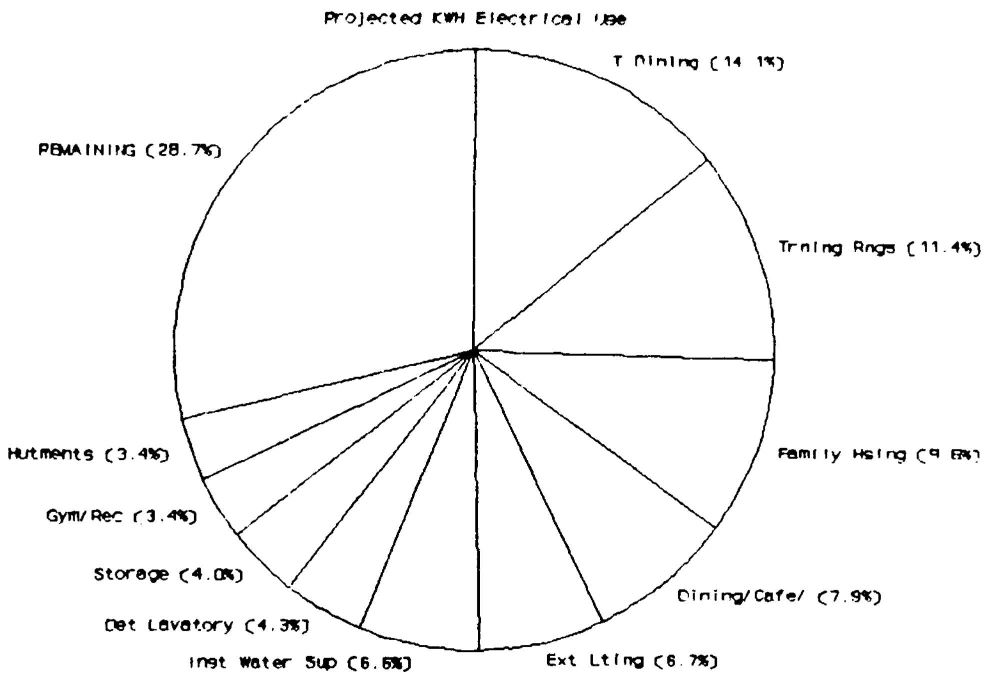
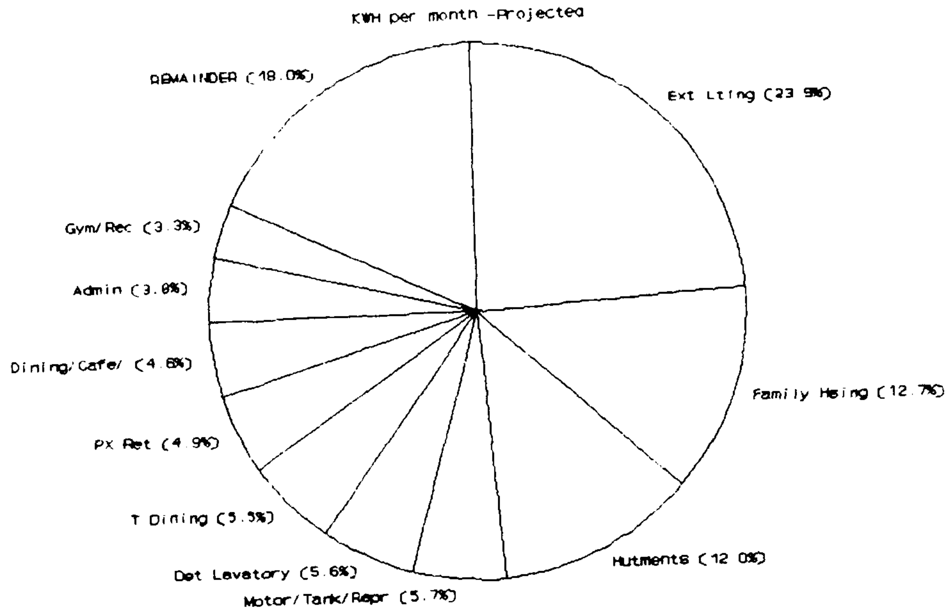


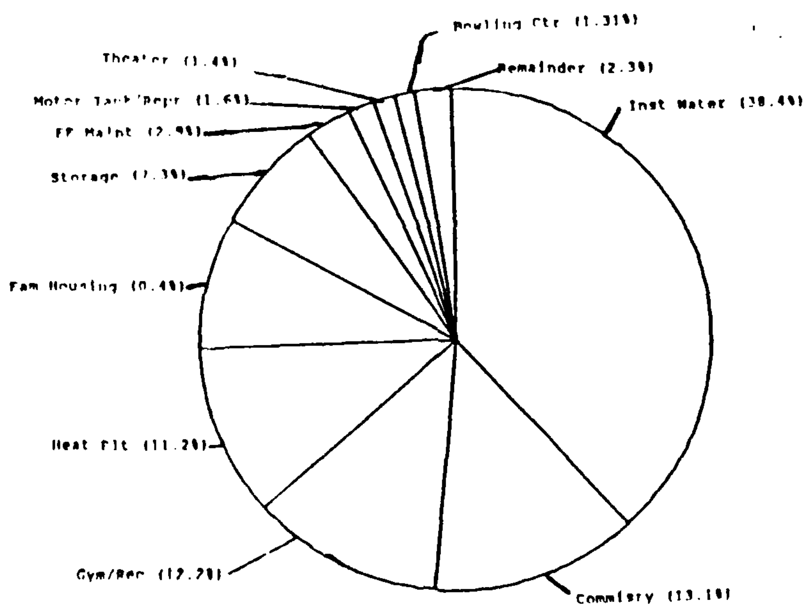
Figure 42. Grafenwöhr's projected major kWh users by building category.

NO.	BLDG CATEGORY	% OF TOTAL	PROJ. KWH (monthly)	KWH (monthly) LIGHTING	KWH (monthl MOTORS	KWH (monthly MISSION	KWH (monthly) SUPPORT
16	T Dining	14.05	278429	30707	220	246000	1503
50	Trning Ranges	11.37	225257	0	0	225257	0
6	Family Hsing	9.58	189863	70362	28372	68796	22333
8	Dining/Cafe/	7.88	156141	25306	0	130321	515
48	Ext Lting	6.71	132972	132972	0	0	0
47	Inst Water Sup	6.59	130465	0	130465	0	0
43	Det Lavatory	4.29	85013	31092	0	0	53922
4	Storage	3.96	78442	14970	24724	14970	23777
35	Gym/Rec	3.45	68337	18229	41280	5739	3089
12	Hutments	3.43	68036	66734	0	0	1302
3	Motor/Tank/Repr	3.30	65283	31689	5533	22607	5454
49	Airfld Area	3.20	63474	4092	136	57841	1405
1	Admin	2.87	56794	21324	1472	18767	15231
27	Bowl Ctr	2.79	55180	13791	4292	11590	25506
11	Heat Plt	2.55	50448	1718	37995	10296	439
9	Commisry	2.42	48006	2962	44480	255	309
30	PX Ret	2.19	43360	26972	22	10030	6336
23	FE Maint	1.49	29493	4618	9958	9080	5836
31	PX Branch	0.96	19006	10114	0	4747	4145
18	Tele Exch	0.70	13953	2507	0	10847	599
37	Rec ctr/EM Club	0.65	12906	10237	0	640	2029
25	Laundry	0.60	11879	1626	667	7397	2189
38	Theater	0.55	10929	4585	4612	881	851
40	Misc Shed/Garage	0.52	10259	1417	326	701	7816
7	Troop Hsing	0.50	9876	3364	464	1143	4905
17	School	0.46	9110	5552	39	443	3077
19	Fire Sta	0.35	7011	2184	0	528	4298
5	Medical	0.35	6856	1652	734	3325	1144
33	Club/youth/Scout	0.32	6419	2711	0	23	3685
13	Trng Simulator	0.30	5850	547	97	5116	89
2	Trning	0.26	5206	2949	17	1662	578
14	Missile Maint	0.26	5118	2028	0	1944	1146
39	Class VI	0.19	3837	473	0	2518	846
21	Trning Aids Ctr	0.18	3543	2137	0	231	1176
24	Chapel	0.17	3390	932	0	174	2284
22	POL Pump Sta	0.14	2736	0	2736	0	0
28	Lunch Rm	0.11	2253	344	0	1902	7
20	Service Sta	0.08	1654	741	847	12	54
36	Library	0.08	1620	1031	71	237	282
42	Sentry Sta	0.06	1282	160	0	16	1105
26	Bank	0.04	815	458	25	131	202
41	Post Off	0.02	443	166	11	146	119
32	Art/Craft/Skill	0.01	182	69	0	81	33
10	Cold Stor	0.00	0	0	0	0	0
46	Xmitter	0.00	0	0	0	0	0
29	Child Sup Ctr	0.00	0	0	0	0	0
51	Sewage Plt	0.00	0	0	0	0	0
45	Rock Crush Plt	0.00	0	0	0	0	0
15	Electron Maint	0.00	0	0	0	0	[illegible]
44	Wash Fac	0.00	0	0	0	0	0
34	Commnty ctr	0.00	0	0	0	0	0
	SUBTOTAL	7.8	153953	49621	50185	18954	35193
	TOTALS	100.00	1981125	555518	339594	876397	209615

Figure 43. Grafenwöhr building category projected kWh use (sorted by usage).

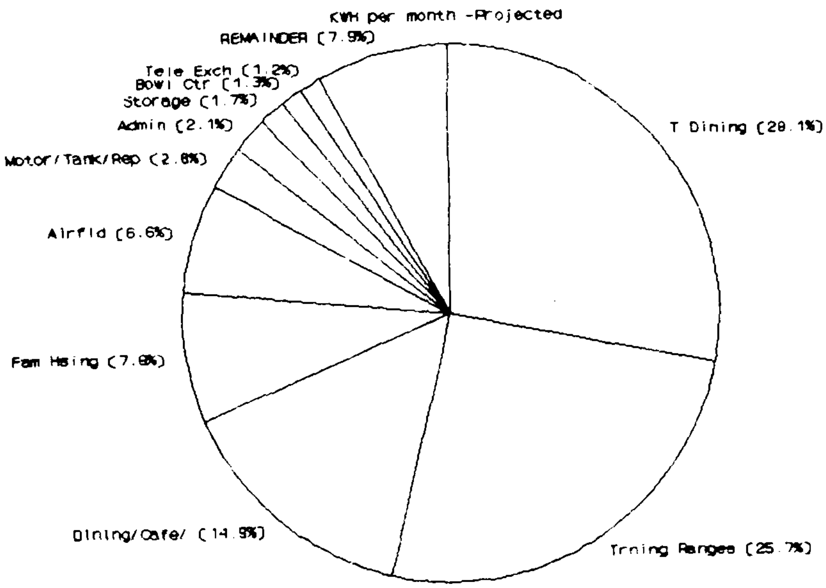


(a)

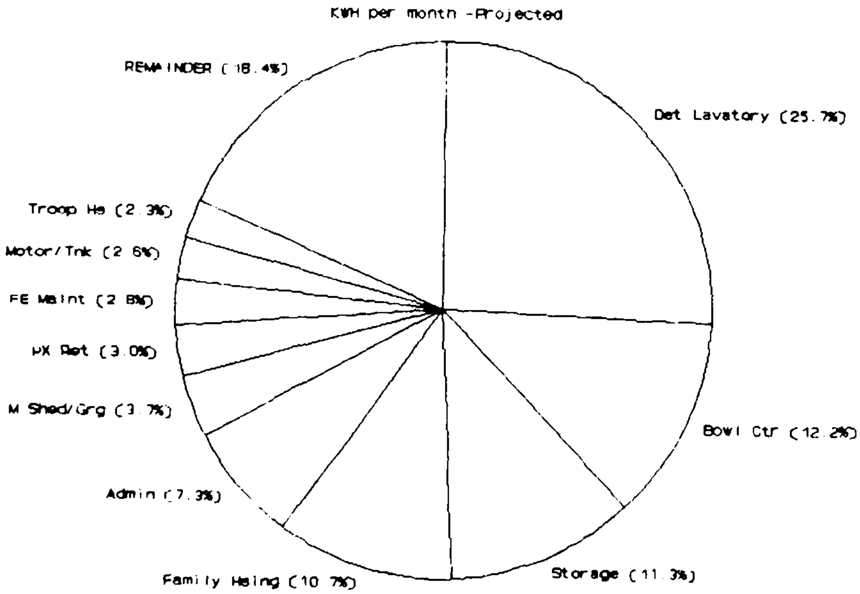


(b)

Figure 44. Grafenwöhr's projected major: (a) lighting users and (b) motor users by building category.

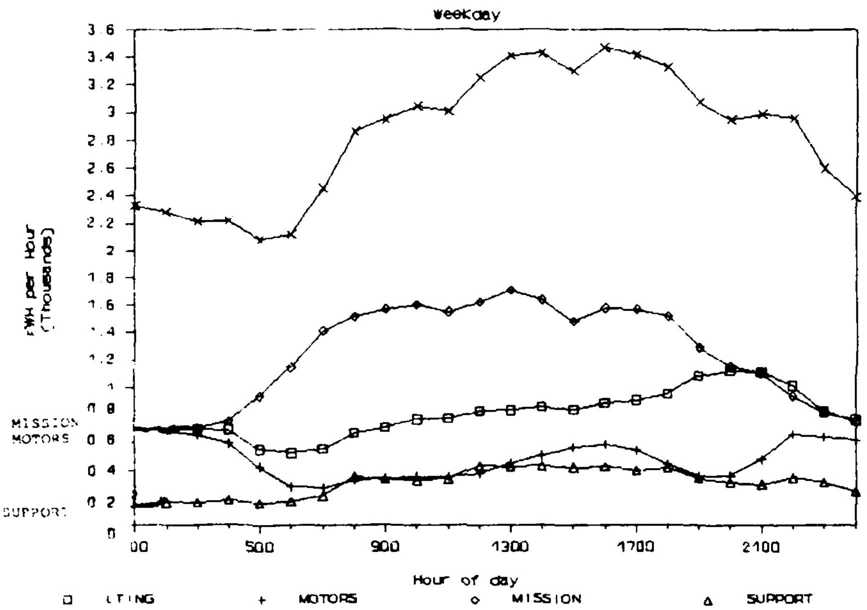


(a)

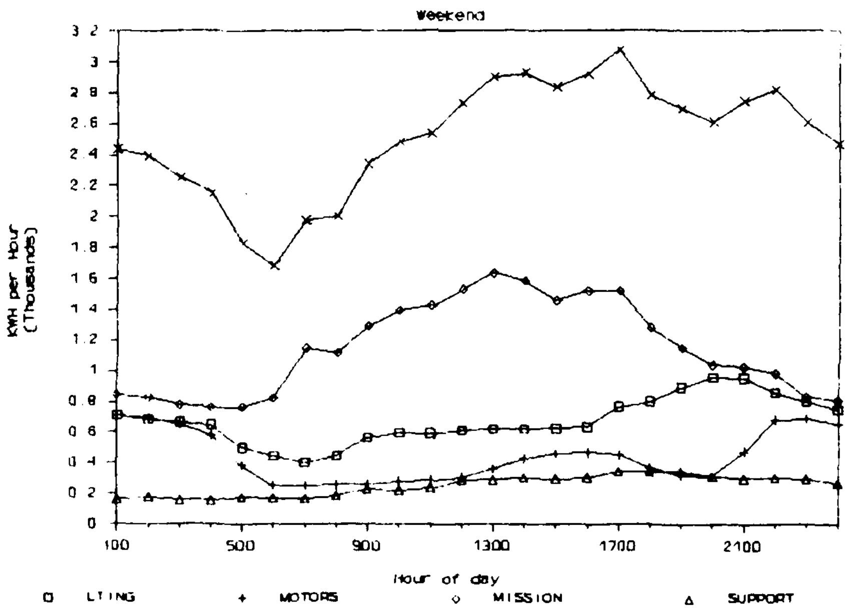


(b)

Figure 45. Grafenwöhr's projected major: (a) mission equipment user and (b) support equipment users by bulding category.



(a)



(b)

Figure 46. Grafenwöhr's projected (a) weekday and (b) weekend profiles and subprofiles.

RANK	BLDG NO.	BLDG DESCRIPTION	BLDG AREA (Sq ft)	BLDG CAT.	LOAD TYPE	5am WkDay KWH/HR
====	====	====================	=====	=====	==========	======
1.	209	Open Mess Officer (F	33639	16	MISSION EQ	32856
2.	150	Commissary	11668	9	MOTORS	30314
3.	2001	EXCHANGE CAFETERIA	15177	8	MISSION EQ	26296
4.	622	Exchange Cafeteria (	13710	8	MISSION EQ	23755
5.	285	Heating Plant Oil Fi	4238	11	MOTORS	17580
6.	242	General Purpose Ware	61469	4	SUPPORT EQ	16030
7.	547	Gymnasium	36984	35	MOTORS	15621
8.	243	General Purpose Ware	55407	4	SUPPORT EQ	14449
9.	445	Open Dining Facility	14223	16	MISSION EQ	13892
10.	3015	OPEN MESS NCO (FORME	13129	16	MISSION EQ	12824
11.	313	Telephone Exchange B	7747	18	MISSION EQ	11927
12.	627	Enlisted Personnel M	10533	16	MISSION EQ	10288
13.	319A2	Facilities Engineer	37344	4	SUPPORT EQ	9739
14.	101	DINING FACILITY	9810	16	MISSION EQ	9582
15.	102	Heating Plant Oil Fi	2299	11	MOTORS	9537
16.	612	BURGER KING (guess S	5500	8	MISSION EQ	9530
17.	501	Enlisted Personnel M	8402	16	MISSION EQ	8207
18.	330	Heating Plant Coal F	1947	11	MOTORS	8076
19.	623	Clothing Sales Store	33027	30	MISSION EQ	7861
20.	245	General Storehouse (	28763	4	SUPPORT EQ	7501
21.	301	Motor Repair Shops W	65820	3	LIGHTING	7116
22.	3002	EXCHANGE CAFETERIA	3908	8	MISSION EQ	6771
23.	329	Facilities Engineer	35155	23	MOTORS	5324
24.	646	Heating Plant Coal F	1128	11	MOTORS	4679
25.	285	Heating Plant Oil Fi	4238	11	MISSION EQ	4651
26.	1264	ENLISTED PERSONNELL	4670	16	MISSION EQ	4561
27.	1284	ENLISTED PERSONNELL	4670	16	MISSION EQ	4561
28.	3104	ENLISTED PERSONNELL	4670	16	MISSION EQ	4561
29.	3124	ENLISTED PERSONNELL	4670	16	MISSION EQ	4561
30.	3364	ENLISTED PERSONNELL	4670	16	MISSION EQ	4561
31.	6134	ENLISTED PERSONNEL M	4670	16	MISSION EQ	4561
32.	3384	ENLISTED PERSONNELL	4670	16	MISSION EQ	4561
33.	3224	ENLISTED PERSONNELL	4670	16	MISSION EQ	4561
34.	3404	ENLISTED PERSONNELL	4670	16	MISSION EQ	4561
35.	3244	ENLISTED PERSONNELL	4670	16	MISSION EQ	4561
36.	3284	ENLISTED PERSONNELL	4670	16	MISSION EQ	4561
37.	3264	ENLISTED PERSONNELL	4670	16	MISSION EQ	4561
38.	623	Clothing Sales Store	33027	30	SUPPORT EQ	4538
39.	600	Bowling Center (AAFE	15051	27	SUPPORT EQ	4465
40.	301	Motor Repair Shops W	65820	3	MISSION EQ	4360
41.	600	Bowling Center (AAFE	15051	27	LIGHTING	4171
42.	319A1	Facilities Engineer	24974	23	MOTORS	3782
43.	534	Golf Club House	8870	35	MOTORS	3747
44.	547	Gymnasium	36984	35	LIGHTING	3676
45.	313	Telephone Exchange B	7747	18	LIGHTING	3423
46.	521	Fire Station	8369	19	SUPPORT EQ	3414
47.	103	Gymnasium	8066	35	MOTORS	3407
48.	618	Heating Plant Oil Fi	819	11	MOTORS	3397
49.	141	Exchange Main Retail	13133	30	MISSION EQ	3126
50.	4424	ENLISTED PERSONNEL M	3101	16	MISSION EQ	3029

Figure 47. Grafenwöhr's top projected loads at 5 a.m. weekdays.

RANK	BLDG NO.	BLDG DESCRIPTION	BLDG AREA (Sq ft)	BLDG CAT.	LOAD TYPE	1pm WkDay KWH/HR
====	====	==================	=====	====	==========	======
1.	2001	EXCHANGE CAFETERIA	15177	8	MISSION EQ	124594
2.	622	Exchange Cafeteria (	13710	8	MISSION EQ	112551
3.	242	General Purpose Ware	61469	4	SUPPORT EQ	59405
4.	623	Clothing Sales Store	33027	30	LIGHTING	57075
5.	243	General Purpose Ware	55407	4	SUPPORT EQ	53547
6.	600	Bowling Center (AAFE	15051	27	SUPPORT EQ	51040
7.	209	Open Mess Officer (F	33639	16	MISSION EQ	48692
8.	547	Gymnasium	36984	35	MOTORS	47205
9.	612	BURGER KING (guess S	5500	8	MISSION EQ	45152
10.	319A2	Facilities Engineer	37344	4	SUPPORT EQ	36090
11.	3002	EXCHANGE CAFETERIA	3908	8	MISSION EQ	32082
12.	150	Commissary	11668	9	MOTORS	31703
13.	612	BOWLING CTR (guess S	9000	27	SUPPORT EQ	30520
14.	245	General Storehouse (	28763	4	SUPPORT EQ	27797
15.	2001	EXCHANGE CAFETERIA	15177	8	LIGHTING	24540
16.	313	Telephone Exchange B	7747	18	MISSION EQ	23684
17.	547	Gymnasium	36984	35	LIGHTING	23153
18.	141	Exchange Main Retail	13133	30	LIGHTING	22696
19.	301	Motor Repair Shops W	65820	3	LIGHTING	22661
20.	622	Exchange Cafeteria (	13710	8	LIGHTING	22168
21.	445	Open Dining Facility	14223	16	MISSION EQ	20587
22.	285	Heating Plant Oil Fi	4238	11	MOTORS	20081
23.	600	Bowling Center (AAFE	15051	27	LIGHTING	19425
24.	3015	OPEN MESS NCO (FORME	13129	16	MISSION EQ	19004
25.	301	Motor Repair Shops W	65820	3	MISSION EQ	17932
26.	329	Facilities Engineer	35155	23	MISSION EQ	17408
27.	627	Enlisted Personnel M	10533	16	MISSION EQ	15246
28.	101	DINING FACILITY	9810	16	MISSION EQ	14200
29.	242	General Purpose Ware	61469	4	LIGHTING	13938
30.	624	Exchange Service Out	13091	31	LIGHTING	12860
31.	243	General Purpose Ware	55407	4	LIGHTING	12564
32.	319A1	Facilities Engineer	24974	23	MISSION EQ	12367
33.	501	Enlisted Personnel M	8402	16	MISSION EQ	12162
34.	533	Applied Instruction	20941	2	LIGHTING	11623
35.	612	BOWLING CTR (guess S	9000	27	LIGHTING	11615
36.	124	Dependent Grade Scho	26586	17	LIGHTING	11589
37.	534	Golf Club House	8870	35	MOTORS	11321
38.	102	Heating Plant Oil Fi	2299	11	MOTORS	10893
39.	623	Clothing Sales Store	33027	30	MISSION EQ	10610
40.	600	Bowling Center (AAFE	15051	27	MISSION EQ	10394
41.	103	Gymnasium	8066	35	MOTORS	10295
42.	207	SNACK BAR	1248	8	MISSION EQ	10245
43.	624	Exchange Service Out	13091	31	MISSION EQ	9909
44.	329	Facilities Engineer	35155	23	MOTORS	9770
45.	330	Heating Plant Coal F	1947	11	MOTORS	9226
46.	547	Gymnasium	36984	35	MISSION EQ	9094
47.	607	Exchange Warehouse (	9361	4	SUPPORT EQ	9047
48.	612	BURGER KING (guess S	5500	8	LIGHTING	8893
49.	308	Exchange Warehouse	9018	4	SUPPORT EQ	8715
50.	242	General Purpose Ware	61469	4	MISSION EQ	8706

Figure 48. Grafenwöhr's top projected building loads at 1 p.m. weekdays.

RANK	BLDG NO.	BLDG DESCRIPTION	BLDG AREA	BLDG CAT.	LOAD TYPE	6am WkEND KWH/HR
1.	2001	EXCHANGE CAFETERIA	15177	8	MISSION EQ	40437
2.	150	Commissary	11668	9	MOTORS	36739
3.	622	Exchange Cafeteria	3710	8	MISSION EQ	36528
4.	547	Gymnasium	36984	35	MOTORS	36516
5.	209	Open Mess Officer	33639	16	MISSION EQ	17959
6.	285	Heating Plant-Oil	4238	11	MOTORS	17083
7.	242	General Purpose Whse	61469	4	SUPPORT EQ	16894
8.	243	General Purpose Whse	55407	4	SUPPORT EQ	15228
9.	612	BURGER KING	5500	8	MISSION EQ	14654
10.	313	Telephone Exchange	7747	18	MISSION EQ	11454
11.	3002	EXCHANGE CAFETERIA	3908	8	MISSION EQ	10412
12	319A2	Facilities Engineer	37344	4	SUPPORT EQ	10264
13.	102	Heating Plant-Oil	2299	11	MOTORS	9267
14	623	Clothing Sales Store	33027	30	MISSION EQ	8791
15.	534	Golf Club House	8870	35	MOTORS	8758
16	103	Gymnasium	8066	35	MOTORS	7964
17.	245	General Storehouse	28763	4	SUPPORT EQ	7905
18.	330	Heating Plant Coal	1947	11	MOTORS	7848
19	301	Motor Repair Shops	65820	3	LIGHTING	7724
20.	445	Open Dining Facility	14223	16	MISSION EQ	7593
21.	3015	OPEN MESS NCO	13129	16	MISSION EQ	7009
22	627	Enlisted Personnel Mess	10533	16	MISSION EQ	5623
23.	600	Bowling Center AAFES	15051	27	SUPPORT EQ	5302
24.	101	DINING FACILITY	9810	16	MISSION EQ	5237
25.	623	Clothing Sales Store	33027	30	SUPPORT EQ	4604
26.	616	Heating Plant-Coal	1128	11	MOTORS	4547
27	501	Enlisted Personnel Mess	8402	16	MISSION EQ	4486
28.	329	Facilities Engineer	35155	23	MOTORS	4392
29.	285	Heating Plant Oil	4238	11	MISSION EQ	4385
30.	600	Bowling Center AAFES	15051	27	LIGHTING	4171
31.	547	Gymnasium	36984	35	LIGHTING	3666
32.	141	Exchange Main Retail	13133	30	MISSION EQ	3496
33	521	Fire Station	8369	19	SUPPORT EQ	3382
34.	301	Motor Repair Shops	65820	3	MISSION EQ	3372
35	641	Enlisted Men Service	16675	37	LIGHTING	3333
36	207	SNACK BAR	1248	8	MISSION EQ	3325
37.	618	Heating Plant-Oil	819	11	MOTORS	3301
38.	209	Open Mess Officer	33639	16	LIGHTING	3263
39	612	BOWLING CTR	9000	27	SUPPORT EQ	3171
40	623	Clothing Sales Store	33027	30	LIGHTING	3140
41	319A1	Facilities Engineer	24974	23	MOTORS	3120
42	313	Telephone Exchange	7747	18	LIGHTING	3018
43	272	Family Housing	35896	6	MISSION EQ	2978
44	272	Family Housing	35896	6	LIGHTING	2931
45	271	Family Housing	31562	6	MISSION EQ	2867
46	271	Family Housing	[illegible]	6	LIGHTING	[illegible]
47	620	Theater W/Stage	16053	38	LIGHTING	[illegible]
48.	607	Exchange Warehouse	9361	4	SUPPORT EQ	2573
49	651	Guided Missile Maint	7763	14	LIGHTING	2509
50	612	BOWLING CTR	9000	27	LIGHTING	2494

Figure 49. Grafenwöhr's top projected building loads at 6 a.m. weekends.

RANK	BLDG NO.	BLDG DESCRIPTION	BLDG AREA (Sq ft)	BLDG CAT.	LOAD TYPE	5pm WKEND KWH/HR
====	====	===================	=====	====	==========	=========
1.	2001	EXCHANGE CAFETERIA	15177	8	MISSION EQ	81889
2.	622	Exchange Cafeteria	13710	8	MISSION EQ	73973
3.	547	Gymnasium	36984	35	MOTORS	51106
4.	209	Open Mess Officer	33639	16	MISSION EQ	41694
5.	150	Commissary	11668	9	MOTORS	30519
6.	612	BURGER KING	5500	8	MISSION EQ	29676
7.	547	Gymnasium	36984	35	LIGHTING	29125
8.	623	Clothing Sales Store	33027	30	LIGHTING	28826
9.	600	Bowling Center AAFES	15051	27	MISSION EQ	27353
10.	600	Bowling Center AAFES	15051	27	SUPPORT EQ	27050
11.	2001	EXCHANGE CAFETERIA	15177	8	LIGHTING	21542
12.	3002	EXCHANGE CAFETERIA	3908	8	MISSION EQ	21086
13.	622	Exchange Cafeteria	13710	8	LIGHTING	19459
14.	445	Open Dining Facility	14223	16	MISSION EQ	17629
15.	600	Bowling Center AAFES	15051	27	LIGHTING	17444
16.	285	Heating Plant-Oil	4238	11	MOTORS	17056
17.	242	General Purpose Ware	61469	4	SUPPORT EQ	16461
18.	612	BOWLING CTR	9000	27	MISSION EQ	16356
19.	3015	OPEN MESS NCO	13129	16	MISSION EQ	16273
20.	612	BOWLING CTR	9000	27	SUPPORT EQ	16175
21.	272	Family Housing	35896	6	MISSION EQ	15669
22.	271	Family Housing	34562	6	MISSION EQ	15086
23.	243	General Purpose Ware	55407	4	SUPPORT EQ	14837
24.	313	Telephone Exchange	7747	18	MISSION EQ	13078
25.	627	Enlisted Personnel	10533	16	MISSION EQ	13055
26.	534	Golf Club House	8870	35	MOTORS	12257
27.	101	DINING FACILITY	9810	16	MISSION EQ	12159
28.	141	Exchange Main Retail	13133	30	LIGHTING	11462
29.	103	Gymnasium	8066	35	MOTORS	11146
30.	301	Motor Repair Shops	65820	3	LIGHTING	11130
31.	290	Family Housing	25459	6	MISSION EQ	11113
32.	275	Family Housing	25316	6	MISSION EQ	11050
33.	276	Family Housing	25316	6	MISSION EQ	11050
34.	277	Family Housing	25316	6	MISSION EQ	11050
35.	284	Family Housing	25316	6	MISSION EQ	11050
36.	286	Family Housing	25316	6	MISSION EQ	11050
37.	287	Family Housing	25316	6	MISSION EQ	11050
38.	288	Family Housing	25316	6	MISSION EQ	11050
39.	289	Family Housing	25316	6	MISSION EQ	11050
40.	547	Gymnasium	36984	35	MISSION EQ	10846
41.	272	Family Housing	35896	6	LIGHTING	10814
42.	612	BOWLING CTR	9000	27	LIGHTING	10431
43.	501	Enlisted Pers. Mess	8402	16	MISSION EQ	10414
44.	271	Family Housing	34562	6	LIGHTING	10413
45.	319A2	Facilities Engineer	37311	4	SUPPORT EQ	10000
46.	278	Family Housing	22326	6	MISSION EQ	9745
47.	279	Family Housing	22326	6	MISSION EQ	9745
48.	280	Family Housing	22326	6	MISSION EQ	9745
49.	102	Heating Plant Oil	2299	11	MOTORS	9252
50.	641	Enlisted Men Service	16675	37	LIGHTING	9170

Figure 50. Grafenwöhr's largest projected building loads at 5 p.m. weekends.

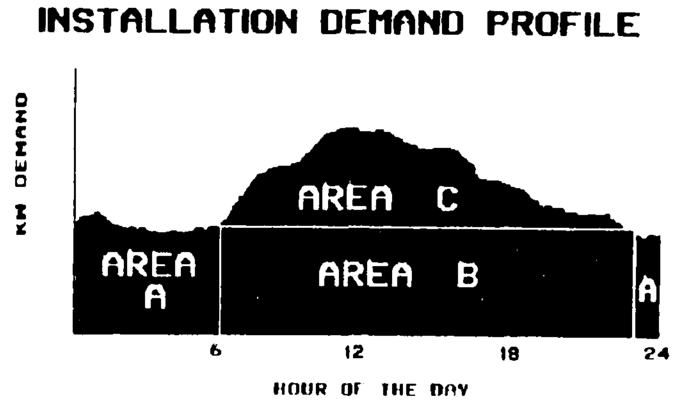


Figure 51. Dissection of Grafenwöhr profile into baseline and peak areas.

Table 14

Grafenwöhr Usage: Night Baseline vs. Day Baseline vs. Day Peak

Projected Baseline vs. Peak kWh Consumption			
	kWh/Day Sum	**Avg**	**% of Total**
Weekday			
Night baseline (2300-0600)	15635	2234	23
Day baseline (0700-2200)	37971		56
Day on-peak (0700-2200)	14548		21
	52519		77
Total	68154		100
Weekend			
Night baseline (2300-0600)	15221	2174	25
Day baseline (0700-2200)	36966		61
Day on-peak (0700-2200)	8030		13
	44996		75
Total	60218		100

7 LIGHTING USAGE AT HOHENFELS AND GRAFENWÖHR

During June and July 1988, a lighting audit was conducted at Grafenwöhr and Hohenfels. Altogether, 76 buildings containing 7358 fixtures were checked during this examination. The audited building area covered approximately 11 percent of the installations' total building areas. In addition, 89 rooms within the audited buildings were checked in greater detail. The information collected included: quantity and type of fixtures in various spaces, random check for lights on while space is unoccupied, condition of spaces that affects lighting, potential for task lighting and daylighting, potential for improved control, and specific fixture information. The warehouse supply of replacement hardware at both communities was also examined.

During the initial visit to each audited building, each space was checked for lights being "on" while the space was unoccupied. Of the 1838 building spaces checked, only 84 (4.6 percent) had lights on while the room was unoccupied. No attempt was made to determine how long the unoccupied room had been vacated. If some tolerance is allowed for occupants who may have stepped out only momentarily, the 4.6 percent number might be reduced further. It appears that building occupants at Hohenfels and Grafenwöhr are conscientious about turning lights off when not needed. Also, in 3.6 percent of the audited spaces, occupants were actually found to be working in the space with the lights turned off.

In each audited building, the number and type of fixtures were recorded. Table 15 is a summary of fixture group totals. From Table 15, 2 by 4 fixtures (2 lamps, 4-ft length) and 1 by 4 fixtures together comprise 54 percent of the fixtures found in the audit.

In addition to audit information on type and quantity shown above, the type of building space where the fixtures were found was also recorded. Audited spaces were classified as one of the following: office space; *functional space*, defined as space used to perform building mission-related activities (varies depending on building type); hallway space; or water closet space. Table 16 shows the total number of fixtures found in each type of space. Functional spaces other than offices contain most of the lighting fixtures found in the audit.

Table 15

Summary of Fixture Types Found During Audit

Fixture Type	No. Found	% of Total
2 x 4 ft	2074	28.2
1 x 4 ft	1924	26.1
4 x 4 ft	731	9.9
4 x 2 ft	639	8.7
incd. (1 lmp)	613	8.3
misc. (1 lmp)	486	6.6
incd. (3 lmp)	173	2.4
2 x 2	124	1.7
1 x 2	122	1.7
other	472	6.4

Table 16

Number of Audit Fixtures Found in Various Spaces

Type of Space	Fixture No.	% of Total
Office space	881	12
Hallway space	634	9
Water closet space	394	5
Functional space (excluding offices)	4355	59
Other (storage, etc.)	1094	15

To examine the use of lighting systems more closely, 89 spaces chosen at random were audited in greater detail. The auditor answered a variety of survey questions that were somewhat subjective. The survey results are shown in Appendix D and the results of each question are discussed below.

Reflectivity of room surfaces can affect overall lighting system efficiency by affecting the quantity and quality of illumination arriving at the work surface after leaving the fixture. Improving poor reflectivity might permit a reduction in the quantity of light output at the fixture while maintaining existing light levels at the work surface. Table 17 summarizes room surface reflectivities for the 89 audited spaces. A closer examination of the data in Appendix D indicates that three of four poorly rated ceilings occurred in spaces with poorly rated walls also. Momentarily ignoring poorly rated floors, which might be considered as secondary in importance, 21 of 89 spaces (24 percent) had poorly reflecting walls and/or ceilings.

Fixture spacing to permit deletions, question Q4 in Appendix D, is intended to identify spaces where fixtures are close enough together that a fixture could be eliminated without creating excessive dark spots. To maintain the lighting level, fixtures adjacent to the deleted fixture would be required to produce a greater light output. However, some energy savings may be possible by using fewer fixtures with greater individual wattage. Twenty-six of 89 spaces (29 percent) met this condition.

Unscheduled blackouts/dimming permissible, questions Q5 and Q6 in Appendix D, indicate spaces where occupants could tolerate remotely controlled unscheduled blackouts or dimming of lights to control peak demand. While such a scenario is uncommon at present, the spread of Energy Management and Control Systems (EMCS), coupled with the increasing use of electronic ballasts (some having built-in digital interface connectors to permit external control), means that the hardware may be in place to allow such an application in the future. The auditor classified 22 of 89 spaces (25 percent) as capable of tolerating unscheduled periods of lights being switched off and 70 of 89 (79 percent) as capable of tolerating some level of unscheduled dimming.

Questions 7 through 13 of Appendix D identify spaces classified as having potential for saving energy through various types of retrofits or operational changes to the lighting system. The various retrofits were considered independently for each space. Thus, any one space may be classified as having potential for using several retrofit options which would obviously not be compatible or practical to imple-

Table 17

Summary of Audit Room Surface Reflectivities

Surface	Surface Rating (%) Good	Fair	Poor
Walls	46	30	24
Ceilings	74	21	5
Floors	30	28	42

ment simultaneously. The most appropriate retrofit would require a comparative analysis. Retrofits that were classified in the audit are:

- (Q7) Task lighting - using desk or table lamps instead of overhead room lighting
- (Q8) Daylighting - turning off or dimming the lighting system when *existing* natural daylight provides adequate illumination
- (Q9) Time control - having timers turn off lights at specified hours of the day
- (Q10) Task level switching - wiring light fixtures (or using dimmers) to permit the lighting (footcandle) level to be varied to match changing activities within the space
- (Q11) Task area switching - using switches to turn off fixtures in unused portions of the space
- (Q12) Improved switch access - locating switches in easily accessible locations, particularly in spaces with multiple exits
- (Q13) Occupant sensors - using sensors to turn lights off after occupants leave the space.

Table 18 provides a summary of the number of spaces with potential for the various retrofit actions listed in Appendix D. It should be remembered that these numbers are based on one audit visit to the space and minimal interaction with occupants. How occupants use the space will affect the applicability of the retrofit options. For example, task lighting may not work in some spaces simply because of occupants' personal preference for the area illumination provided by overhead lighting. In spaces with apparent potential for time control, timers may prove to be unnecessary if occupants perform the function faithfully. For occupancy sensors, the frequency and duration of unoccupied periods created by occupant behavior are key factors in determining applicability.

In addition to the audit information presented above, footcandle measurements of the light level in the 89 spaces were recorded. Measured light levels for each space are shown in Table 19, column 11. Column 12 indicates the appropriate footcandle level for the type of space based on authorized footcandle levels in the *Design Criteria Manual* distributed by the Office of the Chief of Engineers.

Table 18

Summary of Audit Questions Related to Retrofit Potential

Question No.	"Yes" Responses (89 Audited)	% of Total
Q4 - Spacing permits deletions?	25	28
Q5 - Unscheduled shutoff?	24	27
Q6 - Unscheduled dimming?	70	79
Q7 - Could use task lighting?	28	32
Q8 - Existing daylighting?	12	14
Q9 - Time control potential?	52	58
Q10 - Task level switching?	39	44
Q11 - Task area switching?	39	44
Q12 - Improve switch access?	15	17
Q13 - Occupancy sensors?	66	74

Column 13 is a ratio of measured to authorized footcandles for each space. Therefore, numbers significantly greater than one indicate apparent overlighting. Ignoring hallways and water closets, 29 of 74 office and functional spaces had a footcandle ratio greater than 1.2. However, upon reexamination of the space and/or the audit information, many of the 29 high footcandle ratios were likely affected by daylight from existing building fenestration. If the absence of a high lighting wattage in the space (discussed below) is assumed to indicate that daylighting is the likely cause for high footcandles, then 16 of the 29 high footcandle ratios are attributed to daylighting influence. The remaining 13 of 74 (18 percent) office and functional spaces have high footcandle ratios that indicate potentially overlighted spaces.

In addition to natural daylighting, other factors contributing to the potential unreliability of the footcandle ratios are judgmental decisions in determining from the manual the classification of space type that dictates authorized footcandles and the inherent lack of precision in the equipment and method used for field measurements. Also, the authorized footcandles selected from the manual for functional or office spaces where German nationals are working may not match German lighting standards which may have been used to design the lighting system and which would take precedence.

Additional audit information that might be used to supplement footcandle ratios (above) is the watts of lighting per square foot of space, labeled as "power density." Input power (watts) for each of the 89 audited spaces was calculated by assuming a nominal rating for each type of fixture to be multiplied by the number of fixtures. For example, 2 by 4 fluorescent fixtures rated at 96 W multiplied by the number of fixtures yields the watts of lighting for the space. To compare power density (watts per square foot) for various spaces, the calculated wattage of lighting for each space was divided by the area of the space. The space's area is only an approximate estimate as determined visually during the audit. The calculated power densities (watts per square foot) for each space are shown in Table 19, column 8. Note that for office spaces (room type "a" in column 3), power densities vary from 0.4 to 5.3 W/sq ft. In comparison, the American National Electrical Code specifies 3.5 W/sq ft (over the entire building) for general lighting loads when designing electrical feeders. Direct comparison of power densities shown for the functional spaces (room type "d") is not reasonable because of the radically different functions of the spaces (e.g., hangars, retail, classrooms). Each space type would be expected to have a different power density.

Table 19

Footcandle and Power Density Audit Data

(1) Comm-unity	(2) Bldg No.	(3) Room Type	(4) Room Descr-iption	(5) Audit Watts	(6) Floor Dimensions (Sq ft) L	(7) W	(8) Power Dens-ity (W/Sq ft)	(9) DOE Power Dens-ity	(10) Power Dens-ity Ratio	(11) Aud-it FCs	(12) Auth. FCs	(13) FC Ratio
Graf	129	a	Dr. of	576	9	12	5.33	1.7	3.137	50	50	1.00
Hoh	41	a	office	360	9	11	3.94	1.7	2.318	73	50	1.46
Graf	531	a	lect. of	864	13	29	2.29	1.7	1.348	44	50	0.88
Graf	1030	a	of	192	9	10	2.13	1.7	1.255	31	50	0.62
Graf	602	a	of-4p	576	13	22	2.01	1.7	1.185	74	50	1.48
Graf	441	a	of/cashi	384	10	20	1.92	1.7	1.129	80	50	1.60
Hoh	739	a	of-obser	288	10	15	1.92	1.7	1.121	119	50	2.38
Graf	2025	a	of-produ	540	12	25	1.82	1.7	1.073	14	50	0.28
Hoh	1A	a	of-4p	576	17	19	1.78	1.7	1.049	60	50	1.20
Hoh	270	a	of	870	22	26	1.52	1.7	0.895	44	50	0.88
Hoh	12	a	of-5p	384	13	21	1.41	1.7	0.827	45	50	0.90
Graf	2026	a	of	121	9	10	1.34	1.7	0.791	20	50	0.40
Graf	531	a	of-3p	384	17	18	1.25	1.7	0.738	52	50	1.04
Hoh	49	a	libr/of	1308	32	36	1.15	1.7	0.674	48	50	0.96
Graf	141A	a	of	252	16	16	0.98	1.7	0.579	45	50	0.90
Hoh	17	a	of	180	14	14	0.92	1.7	0.540	50	50	1.00
Graf	129	a	of/exam	312	18	22	0.81	1.7	0.477	17	50	0.34
Graf	500	a	of	96	9	14	0.76	1.7	0.448	13	15	0.87
Hoh	9	a	of-2p	96	11	12	0.71	1.7	0.418	21	50	0.42
Hoh	745	a	of	96	12	12	0.67	1.7	0.392	31	50	0.62
Hoh	703	a	of-files	432	28	36	0.43	1.7	0.252	20	50	0.40
Hoh	42	b	wait/hal	1620	21	25	3.09	0.8	3.857	65	15	4.33
Hoh	20	b	hall	900	6	76	1.97	0.8	2.467	10	10	1.00
Graf	547	b	hall/exe	960	6	100	1.60	0.8	2.000	16	10	1.60
Hoh	17	b	hall	720	6	76	1.58	0.8	1.974	10	10	1.00
Hoh	5	b	hall	600	7	60	1.54	0.8	1.923	33	10	3.30
Hoh	1A	b	hall3	680	8	142	0.60	0.8	0.748	10	10	1.00
Hoh	745	b	hall	336	6	96	0.58	0.8	0.729	14	10	1.40
Graf	500	b	hall 1fl	144	7	63	0.33	0.8	0.408	20	10	2.00
Graf	531	b	hall	126	6	83	0.25	0.8	0.316	21	10	2.10
Hoh	3	c	W-WC	296	10	16	1.85	0.8	2.313	20	20	1.00
Graf	547	c	W - lock	636	14	28	1.62	0.8	2.028	28	15	1.87
Graf	500	c	WC -m/f	144	13	19	0.58	0.8	0.729	75	20	3.75
Hoh	174	c	sink rm	96	17	20	0.29	0.8	0.364	18	20	0.90
Hoh	703	c	W-WC	60	6	35	0.29	0.8	0.357	15	30	0.50
Hoh	174	c	shower r	48	11	17	0.25	0.8	0.314	15	20	0.75
Graf	129	d	dr exam	876	9	11	9.37	1.6	5.856	64	50	1.28
Hoh	42	d	classroo	900	8	13	9.23	1.8	5.128	75	50	1.50
Graf	107	d	rm3	1536	13	19	6.33	1.6	3.955	88	50	1.76
Graf	2442	d	laundry	3360	32	35	3.00	1.0	3.000	32	15	2.13
Graf	101	d	dish was	1680	21	21	3.81	1.4	2.721	49	15	3.27

Table 19 (Cont'd)

Hoh	40	d	multi pu	5850	31	101	1.87	0.7	2.669	22	30	0.73
Graf	602	d	conferen	1440	16	21	4.39	1.8	2.439	72	30	2.40
Graf	105	d	lobby	2364	23	46	2.23	1.0	2.234	24	10	2.40
Hoh	88	d	hnd ball	2304	20	40	2.88	1.3	2.215	37	20	1.85
Graf	2026	d	hangar	2152	32	32	2.10	1.0	2.102	18	75	0.24
Hoh	H15	d	retail s	2112	24	51	1.76	3.3	0.530	45	25	1.80
Hoh	12	d	warehous	2880	41	119	0.59	0.3	1.968	12	10	1.20
Graf	101	d	food pre	1008	15	25	2.69	1.4	1.920	40	70	0.57
Hoh	169	d	retail	2490	20	21	6.08	3.3	1.843	30	30	1.00
Graf	2025	d	hangar	3996	46	49	1.77	1.0	1.773	21	50	0.42
Hoh	41	d	lobby/of	2250	14	33	4.87	2.8	1.739	55	50	1.10
Graf	212	d		186	9	12	1.72	1.0	1.722	22	5	4.40
Graf	2008	d	tank sim	1464	26	55	1.02	0.6	1.706	18	30	0.60
Hoh	169	d	stock rm	384	15	52	0.49	0.3	1.641	7	30	0.23
Graf	141	d	? furnis	4238	16	56	4.77	3.0	1.591	52	30	1.73
Graf	1030	d	class rm	2292	23	35	2.87	2.0	1.437	27	50	0.54
Hoh	5	d	classroo	2160	27	28	2.86	2.0	1.429	82	50	1.64
Graf	622	d	eating a	5676	42	29	4.66	3.3	1.412	18	25	0.72
Hoh	88	d	L-lock	384	15	25	1.02	0.8	1.280	10	20	0.50
Hoh	17	d	dorm	180	11	14	1.17	1.0	1.169	41	30	1.37
Hoh	2045	d	hangar	2700	75	106	0.34	0.3	1.132	23	50	0.46
Graf	319	d	warehous	7002	70	91	1.10	1.0	1.099	17	20	0.85
Graf	124	d	class rm	1344	20	31	2.17	2.0	1.084	70	50	1.40
Graf	124	d	class rm	1344	20	32	2.10	2.0	1.050	64	50	1.28
Graf	141A	d	retail	1632	10	48	3.40	3.3	1.030	29	30	0.97
Hoh	3c	d	eating	2958	38	58	1.34	1.5	0.895	30	25	1.20
Hoh	50	d	game rm1	960	36	48	0.56	0.7	0.794	18	20	0.90
Graf	1008	d	retail	3054	22	57	2.44	3.3	0.738	27	30	0.90
Hoh	36	d	bay area	960	30	46	0.70	1.0	0.696	100	30	3.33
Hoh	88	d	gym	4368	75	88	0.66	1.0	0.662	44	30	1.47
Hoh	49	d	libr rm2	1212	32	37	1.04	1.6	0.649	35	50	0.70
Graf	445	d	dining	3440	48	51	1.41	2.2	0.639	11	25	0.44
Graf	148	d	retail r	3324	35	46	2.08	3.3	0.632	43	30	1.43
Hoh	18	d	ceramic	360	18	20	1.00	1.6	0.625	43	20	2.15
Hoh	1A	d	conferen	840	20	38	1.11	1.8	0.614	43	30	1.43
Hoh	10	d	activewa	2592	58	79	0.57	1.0	0.566	16	10	1.60
Hoh	18	d	woodshop	2112	25	65	1.30	2.3	0.565	72	20	3.60
Hoh	14	d	b. lanes	2240	41	90	0.61	1.1	0.552	25	10	2.50
Hoh	10	d	D4 wareh	2496	58	78	0.55	1.0	0.552	24	10	2.40
Hoh	9	d	veh stat	2784	64	84	0.52	1.0	0.518	13	50	0.26
Hoh	2	d	church	1920	37	49	1.06	2.3	0.460	10	30	0.33
Hoh	14	d	b. lanes	2352	41	90	0.64	1.5	0.425	25	10	2.50
Graf	602	d	6baygara	3720	51	98	0.36	1.0	0.361	37	50	0.74
Graf	150	d	retail	7668	61	102	1.09	3.3	0.330	31	30	1.03
Hoh	386	d	class rm	576	28	32	0.64	2.0	0.322	28	50	0.56
Graf	310	d	machine	1920	49	49	0.80	2.5	0.320	27	50	0.54
Hoh	1B	d	grocery	1920	32	88	0.68	3.3	0.207	26	25	1.04
Hoh	270	d	briefing	264	38	54	0.13	1.8	0.072	7	30	0.23

To evaluate the spaces' power densities, a standard for comparison was needed. Power densities from the proposed Voluntary Building Performance Standards published by the U.S. Department of Energy (DOE) were selected for comparison. For each audited space, an attempt was made to select the most appropriate DOE power density number. To aid in the comparison, a ratio of audited watts per square foot vs. DOE authorized watts per square foot was calculated (shown in column 10 of Table 19). A ratio number greater than 1.0 indicates that audited lighting input power exceeds the DOE authorized power input for the space. Note that 32 of 89 ratios (36 percent) exceeded a value of 1.2. In office spaces, only three of 21 spaces exceeded 1.2. In hallways, five of the nine audited hallways exceeded 1.2. In functional spaces, 24 of 53 spaces (45 percent) exceeded 1.2. Of the 24 functional spaces exceeding a 1.2 power density ratio, retail stores accounted for four of the high ratios, and hangars, food service, and classrooms each accounted for three high ratios.

Many power density ratios were high compared with the DOE standard. This result could be a function of the "toughness" of the DOE standard rather than an indication that the lighting systems have excessively high input power densities. Since the DOE standard is being proposed for future building designs, it might be expected that many existing buildings do not meet the standard. No data were obtained to indicate typical values for other existing buildings.

While absolute determination of excessive lighting power input is not possible from the calculated power density ratios, a relative comparison between spaces can indicate "worst-case" spaces that might warrant further inspection for conservation opportunities.

In an attempt to evaluate lighting system efficiency (output to input) for the 89 audited spaces, both ratios (footcandle and power density) calculated above were examined together. When the power density ratio is high and the footcandle ratio is disproportionately lower, energy is being input into the lighting system with a lower-than-expected footcandle output. This condition indicates a low system efficiency. Fifteen of 74 (20 percent) of the audited office and functional spaces exhibited high power density ratios and low footcandle ratios. When both ratios are high, efficiency is apparently satisfactory, but the space may be overlighted. As indicated in the previous discussion of footcandle ratios, 13 of 74 (18 percent) office and functional spaces have high values for both ratios, which indicates potential overlighting.

This examination of footcandle ratios and power density ratios as an evaluation method was selected to use the available lighting survey information. It is recognized that several assumptions were made in the analysis, and that a follow-up field examination of the spaces would be desirable for a better understanding of factors contributing to the data. In addition to the desire to present data analysis results from this survey, the footcandle and power density ratios are presented as examples of survey and analytical methods that might be useful to installation energy personnel in identifying locations with potential energy conservation opportunities.

Examination of footcandle and power density ratios indicated conditions of (1) overlighted spaces and (2) inefficient lighting systems in spaces. Below are some of the commonly used retrofit actions for these conditions.

Reducing Overlit Spaces

Delamping

The lamps in a fluorescent fixture can be disconnected or single lamps replaced by phantom tubes that allow for normal operation of the fixture. A phantom tube is a lamp that contains a capacitor and

emits no light. When combined with reflectors or task lighting, less drastic reductions in illuminance levels can be achieved. Delamping may be infeasible where one-lamp fixtures are in use or when activities in the room require an even light pattern.

Reflectors

Reflectors are carefully designed, highly reflective sheets of silver or aluminum that are installed in fluorescent fixtures. Manufacturers recommend them as a retrofit in four-lamp fixtures and claim that about the same light level can be maintained by removing two lamps and installing reflectors. The reflectors tend to focus the light beneath the fixture, changing the light distribution patterns. Care should be taken to ensure that the new distribution pattern and light levels at various locations will be acceptable before performing retrofits. Installation cost may be significant.

Task Lighting

In many office spaces, lighting consists of several overhead fluorescent fixtures. In areas where computer work is being done, this arrangement can be disturbing. Fluorescent desk lamps at work stations would allow personnel to adjust lighting to their preference as well as reduce energy costs. Areas where task lighting was not a feasible solution were noted in the audit.

Deletions

In rooms with numerous fixtures, simply eliminating some lamps would reduce consumption significantly. In some cases, the spacing of the luminaires will not allow for deletions. Hallways and other spaces where critical activities do not occur are good candidates for fixture deletions.

Correcting Inefficient Lighting Systems

If the power density ratio is too high compared with the footcandle ratio, energy is being used ineffectively. Often, the room has a very poor footcandle measurement for its activities. Power use must be reduced while light output is increased.

Room Reflectivity

Many of the rooms with ineffective lighting seemed to have problems with the reflectivity of their ceilings, floors, or walls. For each room audited, the surroundings were evaluated. When walls do not reflect light, due to either dirt or dark coloring, energy for lighting is used inefficiently. Possible solutions include paint, tile, mirrors, and maintenance.

Tasklighting

See *Tasklighting* in the previous section.

Replacement

Existing incandescent bulbs should be replaced by compact fluorescent bulbs wherever possible. With 10 times the life and one-eighth the operating cost, a compact fluorescent bulb will drastically cut energy use. However, due to the higher initial cost, a retrofit should be implemented only if the compact fluorescent bulb will be used often enough for a short payback period.

Newer electronic ballasts operate lamps at higher frequencies (20,000 Hz). Also, the solid-state ballast has lower power losses than core-coil ballasts. These ballasts allow fluorescent lights to achieve higher lumens per input watts.

Daylighting

When exploited properly, the free energy and light from the sun not only can reduce lighting energy, but also improve lighting quality. Benefits include reduction in light use and improved illuminance. Drawbacks include increased solar heat gain (in summer), infeasible nighttime use, and expensive installation when not already present.

Fixture Maintenance

Dirty fixtures and aged bulbs cause lighting to be inefficient. Since the design lighting level of new lighting systems must allow for deterioration over time, spaces with new systems may be overlighted initially. A routine maintenance program permits designers of new lighting systems to include a smaller margin of overlighting to compensate for anticipated system deterioration.

8 ELECTRIC MOTOR USAGE AT HOHENFELS AND GRAFENWÖHR

Electric motor usage was evaluated at Hohenfels and Grafenwöhr based on information obtained from a field audit, manufacturer's information, and a limited amount of field motor testing.

Field Audit of Motors

The first activity in the motor field audit was to collect manufacturer's nameplate data directly from motors found in use. The information sought at each field site is indicated in Figure 52, "Building Data Information Form," Figure 53, "Motor Data Information Form," and Figure 54, "Preliminary Measured Motor Test Data Form." The appropriate information for the (nearly) 545 audited motors was entered on these forms. The actual recording of field information was performed using audiovisual equipment (camcorder). Later, the information was transcribed to a computer data base for analysis and printing.

In selecting buildings to audit for motors, an attempt was made to have a variety of building categories represented (as defined in Chapter 2). (Note that preliminary building category numbers used in this survey differ slightly from the revised building category numbers used elsewhere in this report.) Tables 20 and 21 present the list of buildings audited for motors along with building area, sample area percentage of building category area, and the number of motors at each building for Grafenwöhr and Hohenfels, respectively. Using the ratio of audited area to total building category area, it is possible to arrive at a multiplier that can be used to project an expected number of motors and kilowatt load for each building category. Tables 22 and 23 list these projected numbers for Grafenwöhr and Hohenfels, respectively. (These numbers are discussed below.) Statistical data for projected numbers have not yet been calculated, but considering the small number of samples in each building category group, the standard deviation could be rather large. Therefore, projected numbers are presented as "ballpark" figures. Table 24 shows the projected number of motors and projected kilowatt load for Grafenwöhr and Hohenfels (combined).

To identify motor usage, each audited motor was classified by application. Motor application groups were defined for building heating, ventilating, and air-conditioning (HVAC), refrigeration (non-HVAC), air compressors, pumping, and other categories. It was further recognized that each general category has numerous subgroupings. Each major category and subgroup was assigned a code. Figures 55 through 59 show the application codes. Tables 25 and 26 indicate the number of motors, kilowatt size, and total code kilowatts for each code number within profiles at Grafenwöhr and Hohenfels, respectively. Tables 27 and 28 list total motors for each application code (disregarding the building category of the building where the motor is found).

Tables 29 and 30 list the number of motors of various sizes for each application code. The sizes are grouped below as 1 kW, 1 to 10 kW, and above 10 kW. The field audit is summarized below in three sections:

- *Total population*, where derivation of the estimated total number of motors and kilowatt load is discussed and related to building profiles
- *Motor application*, where the distribution of motor applications patterns is presented.
- *Motor size distribution*, where the distribution of motor input power is discussed.

DATE: ____________ | VIDEO TAPE #: ________ | TAPE COUNT: START ________ FINISH ________

BASE: GRAFENWOHR ______ HOHENFELS ______

BUILDING #: __________ | BUILDING DESCRIPTION: ______________________________

SQUARE FOOT AREA: ____________ | NUMBER OF FLOORS: ____________

BASEMENT: yes_____ no_____ | ATTIC: yes______ no______

NUMBER OF THREE PHASE INDUCTION MOTORS FOUND: ______________

MOTOR TYPES FOUND

AIR CONDITIONING: no ______
yes ______ If yes, PKG OR WINDOW ______
DIRECT EXPANSION ______
CHILLED WATER ______
ROOFTOP COMPRESSOR/
CONDENSER UNIT ______
OTHER ______

COOLING TOWER: no ______
yes ______ | VENT FANS: no ______
yes ______

TYPE OF HEAT: Furnace Hot Air ______
Boiler Hot Water ______
Steam ______
Central Heat Plant Steam ______
Hot Water ______

COMMENTS: ____

form 1

Figure 52. Building data information form.

BUILDING #:	NO.	OF
DATE:	VIDEO TAPE #.	TAPE COUNT:
APPLICATION :		
COMMENTS:		
MANUFACTURER:		
MODEL #:	(circle) PART OR I.D.	OTHER #:

KW: HP:	SERVICE FACTOR:		ENCLOSURE:
COS ●	POWER FACTOR		
RPM:	TIME RATING: % OR CONTINUOUS (circle)		
VOLTS:	PHASE:	HERTZ:	AMPS:
TEMP RISE: deg. C F (circle)		KVA CODE:	
INSULATION CLASS:		NEMA DESIGN:	
NEMA NOMINAL EFF.:		FRAME SIZE:	
TYPE:	CODE:	FORM:	MOTOR STYLE #.
DRIVE END:		OPP. DRIVE END:	
SERIAL #:		SERIAL CODE:	

COMMENTS:

Figure 53. Motor data sheet.

HOHENFELS: ☐ | GRAFENWOHR: ☐

MOTOR TEST DATA REFERENCE

BUILDING #: ______________ | SHEET #: ______________ OF ______________

PHASE VOLTAGE: RED PHASE________ BLUE PHASE________ BLACK PHASE________
(Line to neutral)

PHASE CURRENT: RED PHASE________ BLUE PHASE________ BLACK PHASE________

POWER INPUT: ______________ KW

QUICK CHECKS:

REACTIVE VOLT AMPS: ______________ K VAR

$KW^2 + KVAR^2 = KVA^2$

TOTAL KVA: ______________ KVA

P.F. = KW / KVA

POWER FACTOR: ______________ % = COSINE (PHASE ANGLE)

COMMENTS: ____

____

____

____

form 3

Figure 54. Preliminary measured motor test data form.

Table 20

Grafenwohr Motor Audit Building List

Bldg No.	Bldg Cat.	Building/Facility Use	Area (sq.Ft)	Motors Per Bldg
621	1	Post Headquarters Building	37921	4
439	1	Ordnance Administration Building	2582	0
2015	1	Provost Marshal & Mil. Police Building	2537	5
Sample Area = 43,040 ft^2 (16% of total profile area)				9
533	2	Applied Instruction Building	20941	1
Sample Area = 20,941 ft^2 (100% of total profile area)				1
602	3	Tank Repair Shops	11984	4
442	3	Exchange Maintenance Shop (Motor)	5991	1
Sample Area = 17,975 ft^2 (6.2% of total profile area)				5
242	4	General Purpose Warehouse (QM)	61469	0
319	4	Facilities Engineer Storehouse	37344	3
419	4	General Storehouse (BW)	5501	2
Sample Area = 104,314 ft^2 (38.3% of total profile area)				5
129A	5	Dispensary With Beds	4590	4
129	5	Dispensary Without Beds	11195	0
Sample Area = 15,785 ft^2 (70.0% of total profile area)				4
119	6	Family Housing Foreign Lt Colonel & Major	7493	3
272	6	Family Housing Foreign NCO	35896	2
276	6	Family Housing Foreign NCO	25316	3
Sample Area = 68,705 ft^2 (12% of total profile area)				8
212	7	Guest House	8855	5
642	7	Enlisted Men Barracks w/o Mess	70324	9
Sample Area = 79,179 ft^2 (15.0% of total profile area)				14

Table 20 (Cont'd)

Bldg No.	Bldg Cat.	Building/Facility Use	Area (sq.Ft)	Motors Per Bldg
209	8	Open Mess Officer	33639	10
2001	8	Exchange Cafeteria	15177	3
1244	8	Enlisted Personnel Mess	3101	0
Sample Area = 51,917 ft^2 (13% of total profile area)				13
150	9	Commissary	11668	4
624	9	Exchange Service Outlets (Foodland)	13091	3
Sample Area = 24,759 ft^2 (100.0% of total profile area)				7
210	11	Heating Plant Oil Fired	462	7
285	11	Heating Plant Oil Fired	4238	18
556A	11	Heating Plant Oil Fired	428	3
102	11	Heating Plant Oil Fired w/conn to 103	2299	4
330	11	Heating Plant Coal Fired	1947	10
603	11	Heating Plant Oil Fired	321	0
618	11	Heating Plant Oil Fired	819	9
619	11	Heating Plant Oil Fired	563	5
646	11	Heating Plant Coal Fired	1128	1
Sample Area = 12,205 ft^2 (100.0% of total profile area)				57
2008	13	Tank Training Simulator	3294	2
2009	13	Tank Training Simulator	3294	0
Sample Area = 6,588 ft^2 (100.0% of total profile area)				2
469	16	Sewage Pumping Station	444	0
Sample Area = 444 ft^2 (100.0% of total profile area)				0
124	17	Dependent Grade School	26586	9
Sample Area = 26,586 ft^2 (55.0% of total profile area)				9
313	18	Tel. Exchange Building (Signal Office)	7747	11
Sample Area = 7,747 ft^2 (100.0% of total profile area)				11

Table 20 (Cont'd)

Bldg No.	Bldg Cat.	Building/Facility Use	Area (sq.Ft)	Motors Per Bldg
245	20	General Storehouse (Silo w/3 Ramps)	28763	0
Sample Area = 28,763 ft^2 (79.0% of total profile area)				0
601	21	Training Aids Center (Range Warehouse)	17403	7
Sample Area = 17,403 ft^2 (34.5% of total profile area)				7
329	23	Facil. Eng. Maintenance Shop (R&U)	35155	4
303	23	Facil. Eng. Facility (RR Crew)	403	0
350	23	Facil. Eng. Maintenance Shop	1967	0
Sample Area = 37,525 ft^2 (55.3% of total profile area)				4
2442	25	Fixed Laundry	3294	5
Sample Area = 3,294 ft^2 (100.0% of total profile area)				5
105	26	Bank (AMEXCO, German Post)	7649	3
Sample Area = 7,649 ft^2 (100.0% of total profile area)				3
600	27	Bowling Center (AAFES Warehouse)	15051	0
Sample Area = 15,051 ft^2 (100.0% of total profile area)				0
304	28	Lunch Room	3788	4
Sample Area = 3,788 ft^2 (90.2% of total profile area)				4
141	30	Exchange Main Retail Store	13133	9
623	30	Clothing Sales Store	33027	4
1021	30	Clothing Sales Store	2585	0
Sample Area = 48,745 ft^2 (100.0% of total profile area)				13

Table 20 (Cont'd)

Bldg No.	Bldg Cat.	Building/Facility Use	Area (sq.Ft)	Motors Per Bldg
2443	31	Exchange Special Support Facilities	3294	0
Sample Area = 3,294 ft^2 (16.0% of total profile area)				0
540	33	Rod-Gun Club	8365	1
Sample Area = 8,365 ft^2 (26.0% of total profile area)				1
103	35	Gymnasium	8066	11
547	35	Gymnasium	36984	26
659	35	Recreation Building	1267	0
333	35	Recreation Building	806	0
Sample Area = 47,123 ft^2 (100.0% of total profile area)				37
107	36	Library Branch	5348	4
Sample Area = 5,348 ft^2 (100.0% of total profile area)				4
641	37	Enlisted Men Service Club W/Terrace	16675	0
2440	37	Enlisted Men Service Club	7744	0
Sample Area = 24,419 ft^2 (69.0% of total profile area)				0
620	38	Theater w/Stage	16053	5
2060	38	Theater w/Stage	11101	6
Sample Area = 27,154 ft^2 (100.0% of total profile area)				11
141A	39	Class VI Store	3018	0
Sample Area = 3,018 ft^2 (100.0% of total profile area)				0
521	40	Fire Station	8369	0
Sample Area = 8,369 ft^2 (76.0% of total profile area)				0

Table 20 (Cont'd)

Bldg No.	Bldg Cat.	Building/Facility Use	Area (sq.Ft)	Motors Per Bldg
1008	41	Post Office Branch	3854	2
Sample Area = 6,069 ft² (100.0% of total profile area)				2
109	42	Elevated Water Storage Tank	8345	0
Sample Area = 10,600 ft² (100.0% of total profile area)				0
468	44	Storage Shed	96	0
Sample Area = 96 ft² (0.1% of total profile area)				0
1225	46	Detached Latrine Building	2000	5
Sample Area = 2,000 ft² (2.1% of total profile area)				5
324	50	Pump Station Above Ground (Pol) (No. 1354)	424	1
373	50	Pump Station Above Ground (Pol)	194	1
371	50	Pump Station Above Ground (Pol)	137	1
372	50	Pump Station Above Ground (Pol)	350	2
Sample Area = 1105 ft² (100.0% of total profile area)				5
334	51	Gasoline Station With Building	1162	0
1033	51	Gasoline Station Building	110	0
Sample Area = 1,272 ft² (48% of total profile area)				0
546	52	Water Pump Stat. Potable	1988	8
4013	52	Water Pump Stat. Potable w/Clorinator	421	0
470	52	Water Pump Stat. Nonpotable (WP "A")	247	0
3492	52	Water Pump Stat. Potable	263	1
Sample Area = 2,919 ft² (80.6% of total profile area)				9
244	56	Standby Gen. Plant W/Oil Stor (DSU)	1022	4
Sample Area = 1,022 ft² (36.0% of total profile area)				4

Table 21

Hohenfels Motor Audit Building List

Bldg No.	Bldg Cat.	Building/Facility Use	Area (sq.Ft)	Motors Per Bldg
1	1	Post Headquarters Building	31255	8
13	1	Administration General Purpose	6866	0
33	1	Engineering Administration Building	5556	0
Sample area = 43,677 ft^2 (30.0 % of total bldg cat. area)				8
42	2	Aces. Facility	6413	1
324	2	General Instruction Building	4343	1
Sample area = 10,756 ft^2 (21.0 % of total bldg cat. area)				2
9	3	Vehicle Maintenance Shop	9047	7
188	3	Div. Brkd Building	2538	0
392	3	Vehicle Maintenance Dir. Sup.	17834	1
Sample area = 29,419 ft^2 (49.0 % of total bldg cat. area)				8
12	4	General Purpose Warehouse	14826	2
34	4	Facilities Storehouse	6770	0
Sample area = 21,596 ft^2 (15.8 % of total bldg cat. area)				2
51	5	Clinic w/beds	22203	7
Sample area = 22,203 ft^2 (100.0 % of total bldg cat. area)				7
8	6	Family Housing Fgn. Enl.	42621	4
60	6	Family Housing CG & W	35665	2
Sample area = 78,286 ft^2 (50.4 % of total bldg cat. area)				6
4	7	Officers Quarters	12335	3
23	7	Enlisted Barracks w/o Dining	22481	14
Sample area = 34,816 ft^2 (23.4 % of total bldg cat. area)				17

Table 21 (Cont'd)

Bldg No.	Bldg Cat.	Building/Facility Use	Area (sq.Ft)	Motors Per Bldg
3	8	Exchange Cafeteria	5076	27
162	8	Enlisted Personnel Dining Facility	4664	9
24	8	Enlisted Personnel Dining Facility	12166	6
Sample area = 21,906 ft^2 (8.9 % of total bldg cat. area)				42
10	10	General Purpose Warehouse	24790	16
Sample area = 24,790 ft^2 (100.0 % Of total bldg cat. area)				16
274	11	Heating Plant	6892	29
320	11	Heating Plant	6700	42
661	11	Heating Plant - Oil Fired	145	4
Sample area =13,737 ft^2 (81.8% of total bldg cat. area)				75
125	12	Hutments	3328	0
Sample area = 3,328 ft^2 (0.7 % of total bldg cat. area)				0
511	15	Electrical Maintenance Shop	16076	1
Sample area = 16,076 ft^2 (67.0 % Of total bldg cat. area)				1
510	16	Sewage Treatment Plant	1200	0
708	16	Sewage Treatment Plant	21989	6
616	16	Chlorination Building	710	13
Sample area = 23,899 ft^2 (100.0 % of total bldg cat. area)				19
5	17	Dep. Grade School	15500	2
Sample area = 15,500 ft^2 (100.0 % of total bldg cat. area)				2
36	23	Facil. Eng. Maintenance Shop	8860	9
35	23	Facil. Eng. Maintenance Shop	6749	2
Sample area = 15,609 ft^2 (41.1 % of total bldg cat. area)				11

Table 21 (Cont'd)

Bldg No.	Bldg Cat.	Building/Facility Use	Area (sq.Ft)	Motors Per Bldg
14	27	Bowling Center	3877	4
Sample area = 3,877 ft^2 (100.0 % Of total bldg cat. area)				4
746	32	Entertainment Workshop	6175	2
Sample area = 6,175 ft^2 (23.9 % of total bldg cat. area)				2
88	35	Gymnasium	22200	21
h-47	35	Racquetball Court	1166	0
47	35	Gymnasium	10951	3
Sample area = 34,317 ft^2 (100.0 % of total bldg cat. area)				24
40	37	Recreation Center	18386	0
Sample area = 18,386 ft^2 (100.0 % of total bldg cat. area)				0
63	39	Class VI Store	1780	0
Sample area = 1,780 ft^2 (13.5 % of total bldg cat. area)				0
512	44	Target Storage	67	0
Sample area = 67 ft^2 (0.02 % of total bldg cat. area)				0
291	45	Rock Crusher Plant	681	5
Sample area = 681 ft^2 (100.0 % of total bldg cat. area)				5
389	51	Exchange Auto Service Station	573	0
522	51	Gas Station	263	1
Sample area = 836 ft^2 (77.1 % of total bldg cat. area)				1
603	52	Pump Station	1808	0
669	52	Pump Station	201	4
276	52	Pump Station	162	0
605	52	Pump Station	410	0
Sample area = 2,581 ft^2 (54.8 % of total bldg cat. area)				4

Table 22

Projected Number of Motors and Load at Grafenwöhr

Bldg Cat. *	Bldg Category Description	No. of Motors Audited	Motor Load (kW)	Audited Area	Total Profile Area	Mult-iply	Pro-jected No. of Motors	Projected kW of Motor Load
1	Administration	9	3.90	43040	143467	3.3	30	13.0
2	Training	1	0.45	20941	20941	1.0	1	0.5
3	Motor/Tank Maint/Rpr	5	4.52	17975	31261	1.7	9	7.9
4	Storage	5	14.65	104314	272360	2.6	13	38.3
5	Medical	8	16.46	17009	17009	1.0	8	16.5
6	Family Housing	8	1.88	68705	941164	13.7	110	25.8
7	Troop Housing	14	5.95	79179	527860	6.7	93	39.7
8	Dining/Cafeteria/Snack	12	2.55	51917	346113	6.7	80	17.0
9	Commissary	7	1.79	24759	24759	1.0	7	1.8
10	Cold Storage							
11	HeatingPlant-Coal/O	57	147.76	12205	12205	1.0	57	147.8
12	Hutments							
13	Training Simulator	2	0.21	6588	6588	1.0	2	0.2
14	Missile Equip Maint Shop							
15	Electronics/Electr Maint Shop							
16	Sewage Treatment Plant	0	0.00	444	444	1.0	0	0.0
17	School	9	5.43	26586	48338	1.8	16	9.9
18	Telephone Exchange	11	8.03	7747	7747	1.0	11	8.0
19	Flight Control,Nav.,Radar							
20	Ammo Storage & Issue	0	0.00	28763	36409	1.3	0	0.0
21	Training Aids Center	6	16.40	17403	511	0.0	0	0.5
22	Maint Aircraft Hangar							
23	Fac Engr Maint Shop	4	4.52	35754	35754	1.0	4	4.5
24	Chapel							
25	Laundry	5	2.51	3294	3294	1.0	5	2.5
26	Bank	3	0.28	7649	7649	1.0	3	0.3
27	Bowling Center	0	0.00	15051	15051	1.0	0	0.0
28	Lunch Room	4	0.52	3788	4200	1.1	4	0.6
29	Child Support Service Ctr							
30	Exchange Retail/Sales	13	15.38	48745	48745	1.0	13	15.4
31	Exchange Branch	0	0.00	3294	10626	3.2	0	0.0
32	Arts/Crafts/Skill Dev Ctr							
33	Club/Youth/Scout Bldg	1	0.08	8365	10456	1.3	1	0.1
34	Community Center							
35	Gymnasium/Rec Bldg	37	79.94	47123	47123	1.0	37	79.9
36	Library	6	0.33	5348	5348	1.0	6	0.3
37	Rec Center/EM Club	0	0.00	24419	35390	1.4	0	0.0
38	Theater	12	13.05	27154	27154	1.0	12	13.0
39	Class VI Store	0	0.00	3018	3018	1.0	0	0.0
40	Fire Station	0	0.00	8369	9197	1.1	0	0.0
41	Post Office	2	0.04	3854	3854	1.0	2	0.0

Table 22 (Cont'd)

Bldg Cat. *	Bldg Category Description	No. of Motors Audited	Motor Load (kW)	Audited Area	Total Profile Area	Mult-iply	Pro-jected No. of Motors	Projected kW of Motor Load
42	Water Storage Tank	0	0.00	8354	8354	1.0	0	0.0
43	Aviation/Airfield Operations							
44	Misc Sheds/Garages/Det	0	0.00	96	495	5.2	0	0.0
45	Rock Crusher Plant							
46	Detached Lavatory	5	4.42	2000	50000	25.0	125	110.4
47	Sentry Station							
48	Rec Fields/Bleachers							
49	Transmitter Bldg (Radio)							
50	POL Pump Station	6	40.55	1105	1105	1.0	6	40.5
51	Service Station	9	157.24	3260	3260	1.0	9	157.2
52	Water Pump Station	2	37.00	931	931	1.0	2	37.0
53	Water Well w/ Pump Station							
54	Wash Facility							
55	Empl Locker Area							
56	Standby Generator	8	53.92	301	502	1.7	13	89.9
0	NOT ASSIGNED	8	119.34	6588			8	119.3
	TOTAL	279	759.08	795435	2768681		688	997.7

* Assigned Bldg Category numbers were revised later (as discussed elsewhere in this report).

Table 23

Projected Number of Motors and Load at Hohenfels

Bldg Cat.*	Bldg Category Description	No. of Motors Audited	Motor Load (kW)	Audited Area	Total Profile Area	Mult-iply	Pro-jected No. of Motors	Projected kW of Motor Load
1	Administration	9	3.56	47005	156683	3.3	30	11.9
2	Training	3	5.645	10756	51219	4.8	14	26.9
3	Motor/Tank Maint/Repair	8	19.36	29419	60039	2.0	16	39.5
4	Storage	2	0.59	21596	107980	5.0	10	2.9
5	Medical	11	2.54	22203	22203	1.0	11	2.5
6	Family Housing	6	4.417	78286	155329	2.0	12	8.8
7	Troop Housing	17	22.25	34816	148786	4.3	73	95.1
8	Dining/Cafeteria/Snack	42	70.03	21906	163478	7.5	313	522.6
9	Commissary							
10	Cold Storage	19	8.23	24790	24790	1.0	19	8.2
11	Heating Plant - Coal/Oi	75	167.66	3199	3199	1.0	75	167.7
12	Hutments	0	0	3328	475429	142.9	0	0.0
13	Training Simulator							
14	Missile Equip Maint Shop							
15	Electronics/Electr Main	1	3	16076	24066	1.5	1	4.5
16	Sewage Treatment Plant	10	487.5	23899	23899	1.0	10	487.5
17	School	2	0.42	15500	15500	1.0	2	0.4
18	Telephone Exchange							
19	Flight Control,Nav.,Radar							
20	Ammo Storage & Issue							
21	Training Aids Center							
22	Maint Aircraft Hangar							
23	Fac Engr Maint Shop	11	15.26	16401	24298	1.5	16	22.6
24	Chapel							
25	Laundry							
26	Bank							
27	Bowling Center	4	4.93	3877	3877	1.0	4	4.9
28	Lunch Room							
29	Child Support Service Ctr							
30	Exchange Retail/Sales							
31	Exchange Branch							
32	Arts/Crafts/Skill Dev C	2	0.02	6175	12654	2.0	4	0.0
33	Club/Youth/Scout Bldg							
34	Community Center							
35	Gymnasium/Rec Bldg	25	53.85	34317	34317	1.0	25	53.9
36	Library							
37	Rec Center/EM Club	0	0	18386	18386	1.0	0	0.0
38	Theater							
39	Class VI Store	0	0	1780	4877	2.7	0	0.0

* Assigned Bldg Category numbers were revised later (as discussed elsewhere in this report).

Table 23 (cont'd)

Bldg Cat. *	Bldg Category Description	No. of Motors Audited	Motor Load (kW)	Audited Area	Total Profile Area	Mult-iply	Pro-jected No. of Motors	Projected kW of Motor Load
40	Fire Station							
41	Post Office							
42	Water Storage Tank							
43	Aviation/Airfield Operations							
44	Misc Sheds/Garages/Deta	0	0	67	67000	1000	0	0.0
45	Rock Crusher Plant	5	55	681	681	1.0	5	55.0
46	Detached Lavatory							
47	Sentry Station							
48	Rec Fields/ Bleachers							
49	Transmitter Bldg (Radio)							
50	POL Pump Station							
51	Service Station	1	13	836	965	1.2	1	15.0
52	Water Pump Station	7	5.31	2581	3483	1.3	9	7.2
53	Water Well w/ Pump Station							
54	Wash Facility							
55	Empl Locker Area							
56	Standby Generator							
0	NOT ASSIGNED	6	60.22				6	60.2
		266	1002.7	437880	1603138		658	1597.3

Table 24

Combined Projected Number of Motors and Load: Hohenfels and Grafenwöhr

Bldg Cat.*	Bldg Category Description	Total No. of Motors Audited	Motor Load (kW)	Audited Area (sq ft)	Total Profile Area (sq ft)	Mult-iply	Pro-jected No. of Motors	Projected kW of Motor Load
1	Administration	18	7.46	90045	300150	3.3	60	24.9
2	Training	4	6.095	31697	72160	2.3	9	13.9
3	Motor/Tank Maint/Repair	13	23.88	47394	91300	1.9	25	46.0
4	Storage	7	15.24	125910	380340	3.0	21	46.0
5	Medical	19	19	39212	39212	1.0	19	19.0
6	Family Housing	14	6.297	146991	1096494	7.5	104	47.0
7	Troop Housing	31	28.2	113995	676646	5.9	184	167.4
8	Dining/Cafeteria/Snack	54	72.58	73823	509591	6.9	373	501.0
9	Commissary	7	1.79	24759	24759	1.0	7	1.8
10	Cold Storage	19	8.23	24790	24790	1.0	19	8.2
11	Heating Plant - Coal/	132	315.42	15404	15404	1.0	132	315.4
12	Hutments	0	0	3328	475429	142.9	0	0.0
13	Training Simulator	2	0.206	6588	6588	1.0	2	0.2
14	Missile Equip Maint Sho	0	0	0	0			
15	Electronics/Electr Main	1	3	16076	24066	1.5	1	4.5
16	Sewage Treatment Plant	10	487.5	24343	24343	1.0	10	487.5
17	School	11	5.85	42086	63838	1.5	17	8.9
18	Telephone Exchange	11	8.03	7747	7747	1.0	11	8.0
19	Flight Control,Nav.,Rad	0	0	0	0			
20	Ammo Storage & Issue	0	0	28763	36409	1.3	0	0.0
21	Training Aids Center	6	16.4	17403	511	0.0	0	0.5
22	Maint Aircraft Hangar	0	0	0	0			
23	Fac Engr Maint Shop	15	19.78	52155	60052	1.2	17	22.8
24	Chapel	0	0	0	0			
25	Laundry	5	2.51	3294	3294	1.0	5	2.5
26	Bank	3	0.28	7649	7649	1.0	3	0.3
27	Bowling Center	4	4.93	18928	18928	1.0	4	4.9
28	Lunch Room	4	0.52	3788	4200	1.1	4	0.6
29	Child Support Service C	0	0	0	0			
30	Exchange Retail/Sales	13	15.38	48745	48745	1.0	13	15.4
31	Exchange Branch	0	0	3294	10626	3.2	0	0.0
32	Arts/Crafts/Skill Dev C	2	0.02	6175	12654	2.0	4	0.0
33	Club/Youth/Scout Bldg	1	0.075	8365	10456	1.3	1	0.1
34	Community Center	0	0	0	0			
35	Gymnasium/ Rec Bldg	62	133.79	81440	81440	1.0	62	133.8
36	Library	6	0.325	5348	5348	1.0	6	0.3
37	Rec Center/ EM Club	0	0	42805	53776	1.3	0	0.0
38	Theater	12	13.045	27154	27154	1.0	12	13.0
39	Class VI Store	0	0	4798	7895	1.6	0	0.0
40	Fire Station	0	0	8369	9197	1.1	0	0.0
41	Post Office	2	0.04	3854	3854	1.0	2	0.0

Table 24 (Cont'd)

Bldg Cat.*	Bldg Category Description	Total No. of Motors Audited	Motor Load (kW)	Audited Area (sq ft)	Total Profile Area (sq ft)	Mult-iply	Pro-jected No. of Motors	Projected kW of Motor Load
42	Water Storage Tank	0	0	8354	8354	1.0	0	0.0
43	Aviation/Airfield Opera	0	0	0	0			
44	Misc Sheds/Garages/Deta	0	0	163	67495	414.1	0	0.0
45	Rock Crusher Plant	5	55	681	681	1.0	5	55.0
46	Detached Lavatory	5	4.417	2000	50000	25.0	125	110.4
47	Sentry Station	0	0	0	0			
48	Rec Fields/ Bleachers	0	0	0	0			
49	Transmitter Bldg (Radio	0	0	0	0			
50	POL Pump Station	6	40.547	1105	1105	1.0	6	40.5
51	Service Station	10	170.24	4096	4225	1.0	10	175.6
52	Water Pump Station	9	42.31	3512	4414	1.3	11	53.2
53	Water Well w/ Pump Stat	0	0	0	0			
54	Wash Facility	0	0	0	0			
55	Empl Locker Area	0	0	0	0			
56	Standby Generator	8	53.92	301	502	1.7	13	89.9
0	NOT ASSIGNED	14	179.56	6588	0	1.0	14	179.6
		545	1761.8	1233315	4371819		1314	2598.2

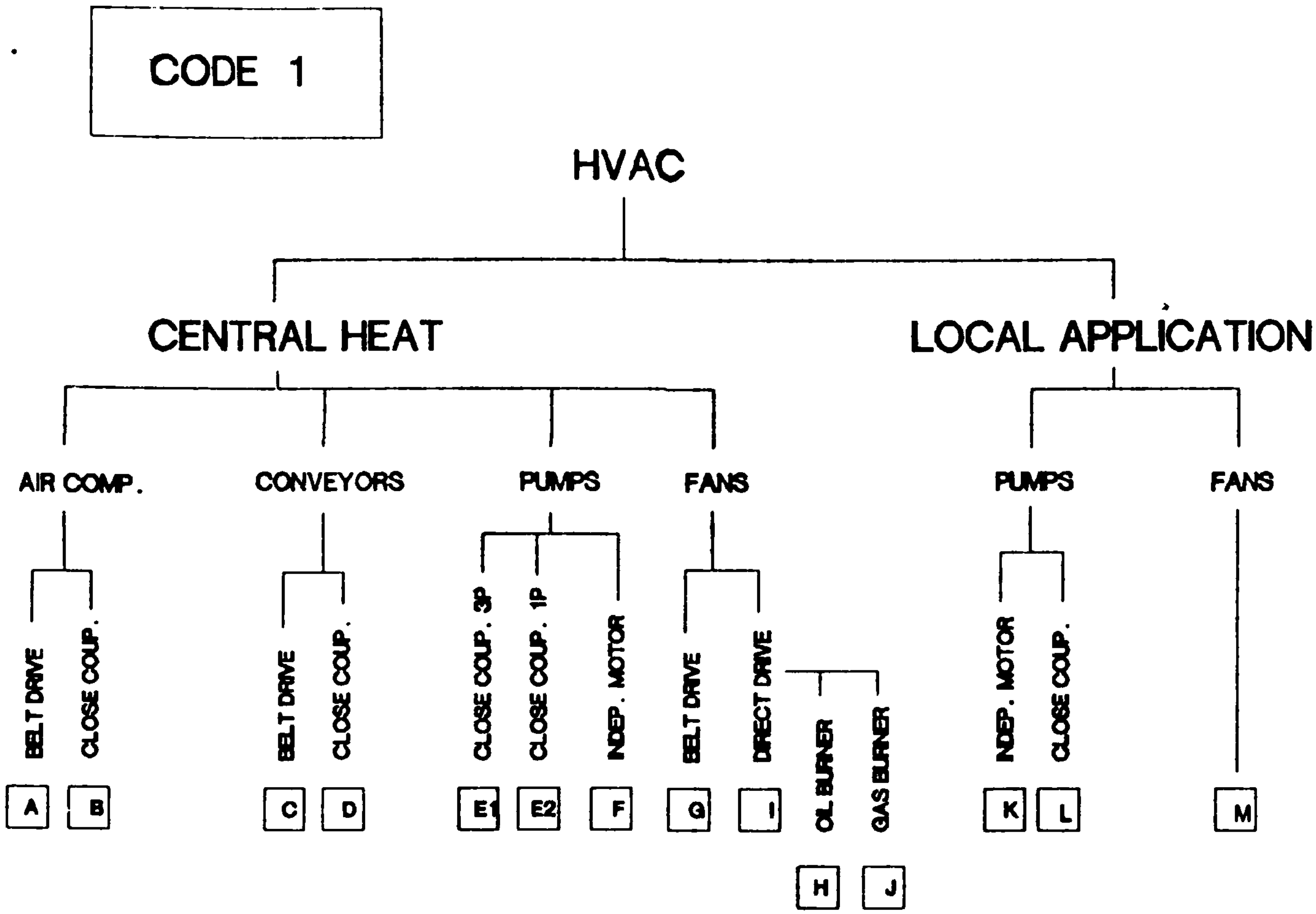


Figure 55. HVAC System motor application categories.

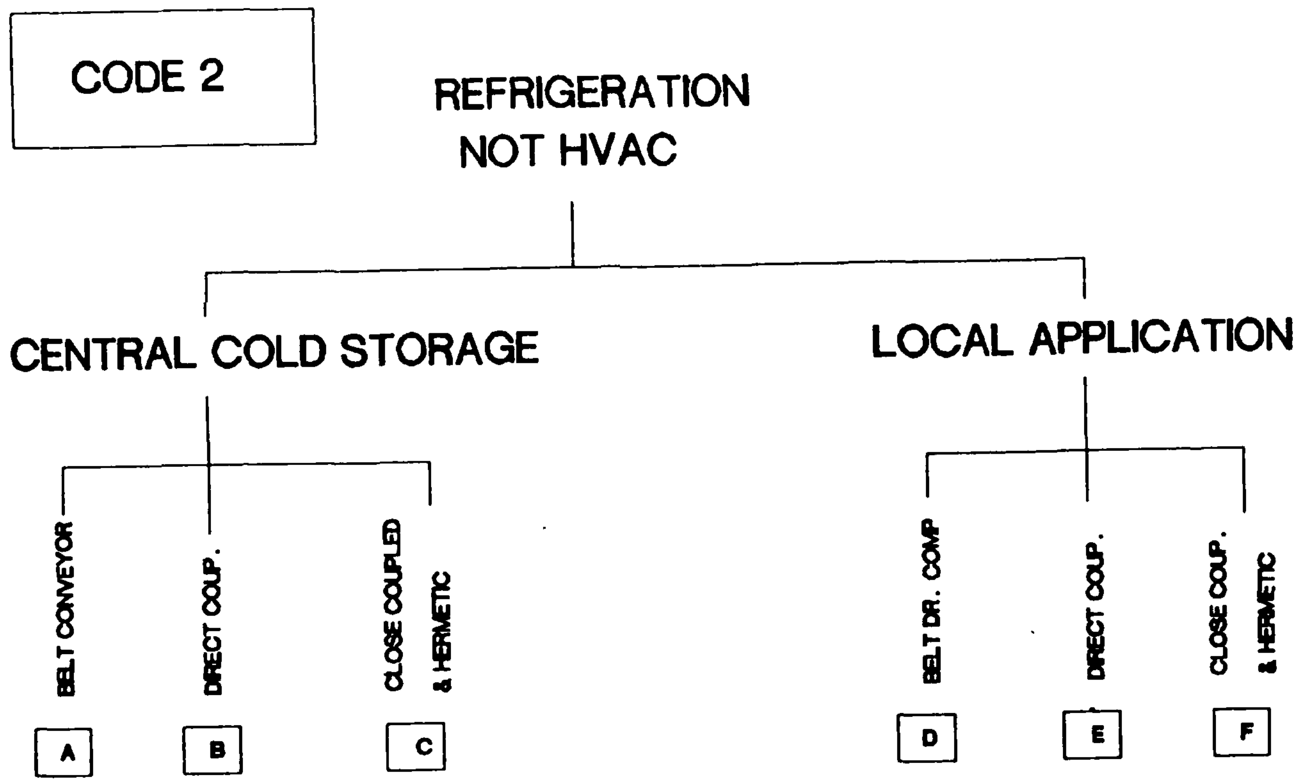


Figure 56. Refrigeration motor application categories.

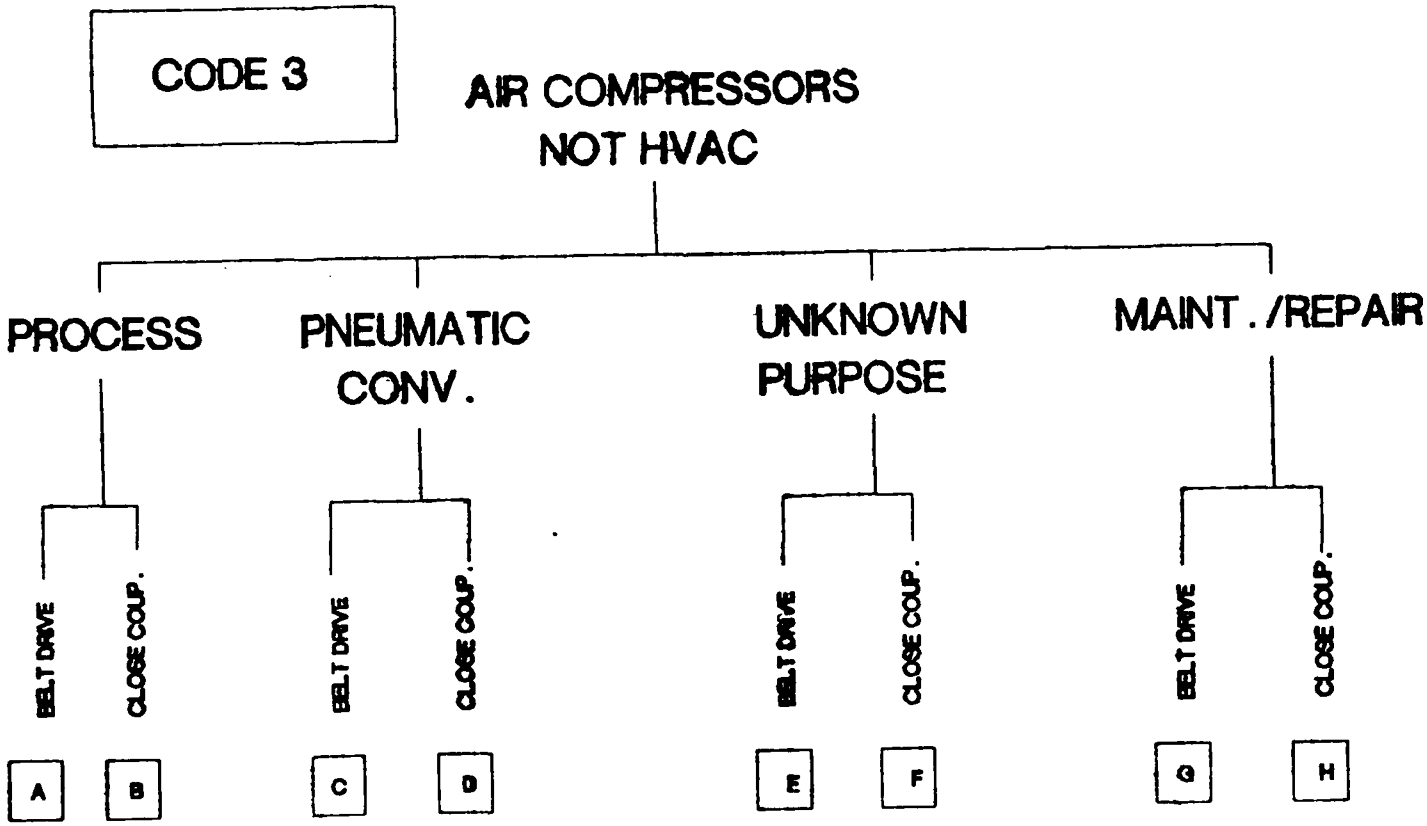


Figure 57. Air compressor motor application categories.

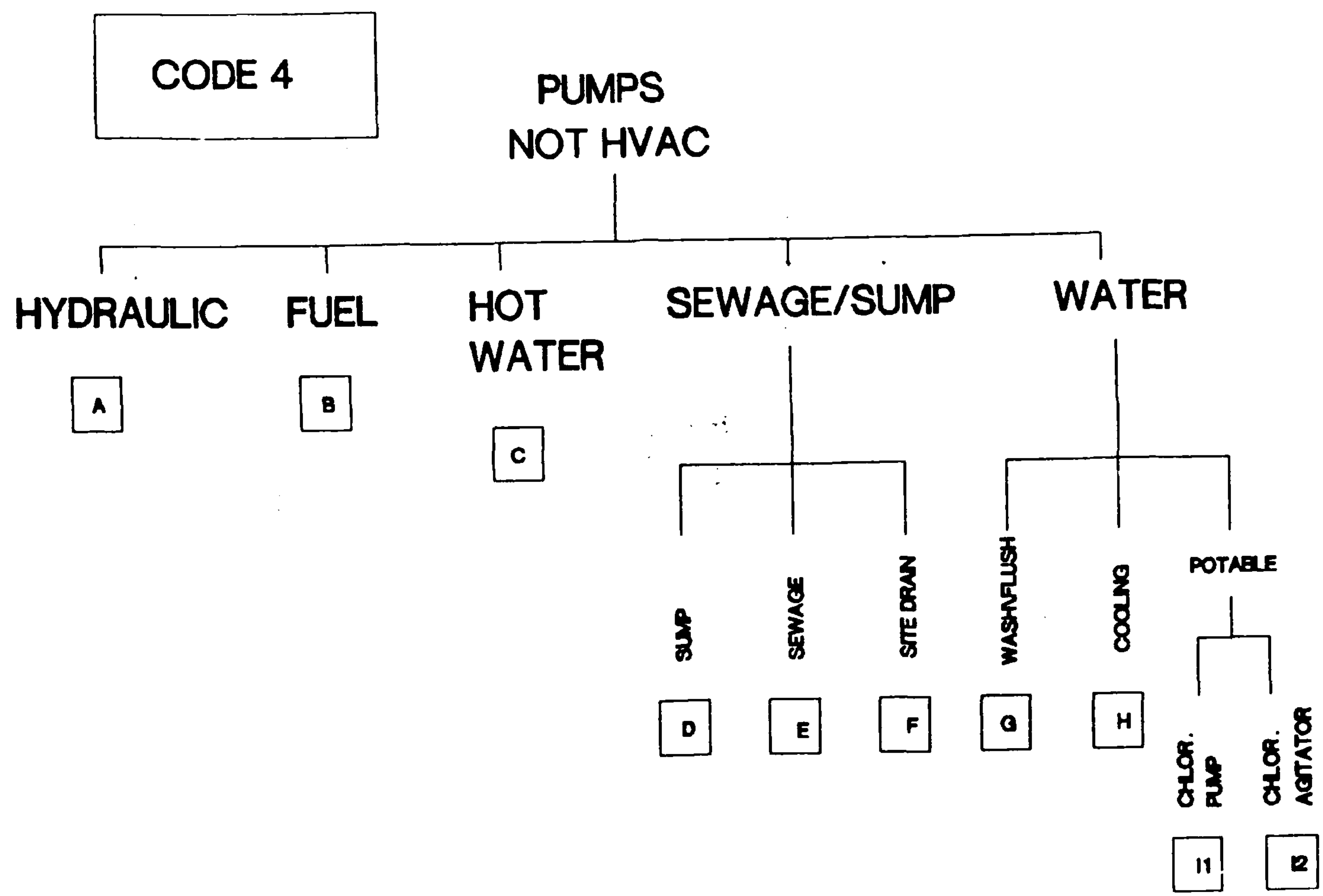


Figure 58. Pumping motor application categories.

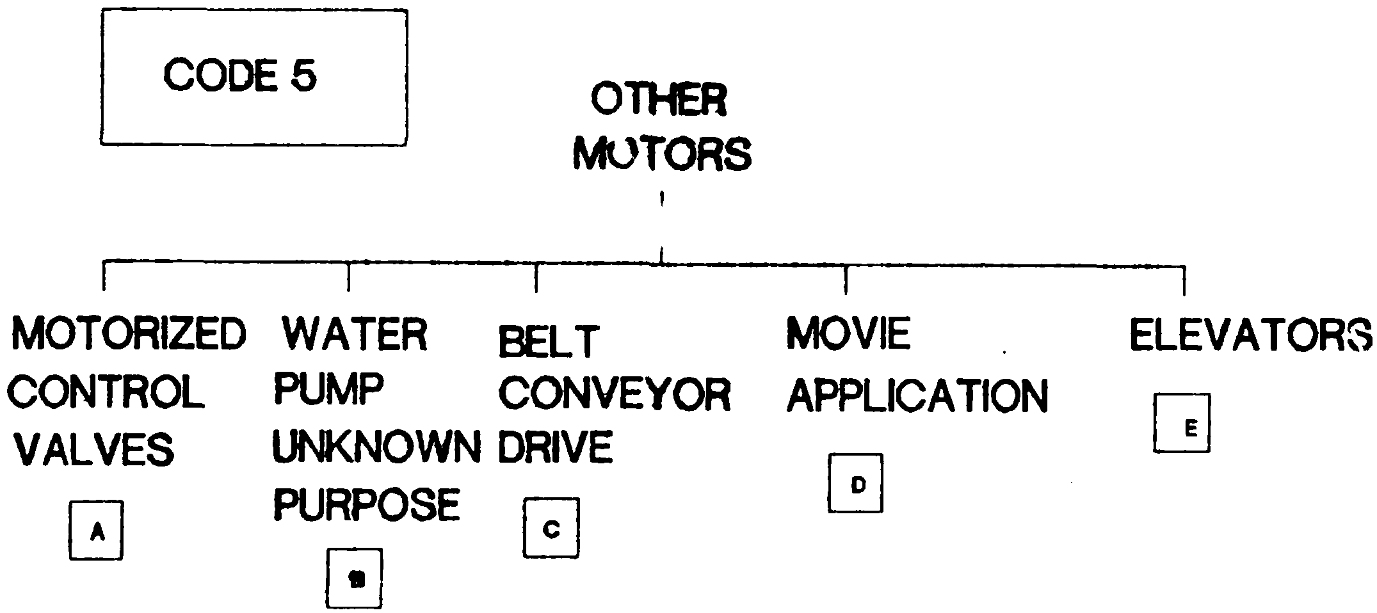


Figure 59. Other motor application categories.

Table 25

Motors Surveyed at Grafenwöhr by Profile, Application, and Power

	Profile Number	Code Number	Total Motors Per Code	Power (kW)			Total Power Per Code (kW)
				Below 1	1 - 10	Above 10	
	0	1H	1	--	1	--	2.60
		3G	1	--	1	--	2.20
		4C	2	--	--	2	110.00
		4F	2	1	1	--	4.32
		4G	2	2	--	--	0.22
Subtotals:			8	3	3	2	119.34
	1	1E1	4	4	--	--	1.20
		1H	1	1	--	--	0.10
		1I	4	3	1	--	2.61
Subtotals:			9	8	1	--	3.91
	2	1E1	1	1	--	--	0.45
Subtotals:			1	1	--	--	0.45
	3	1K	4	4	--	--	0.52
		3G	1	--	1	--	4.00
Subtotals:			5	4	1	--	4.52
	4	1E1	1	--	1	--	4.20
		1I	2	2	--	--	1.45
		3G	1	--	1	--	9.00
		3H	1	--	--	--	--
Subtotals:			5	2	2	--	14.65
	5	1E1	3	3	--	--	1.01
		1E2	4	4	--	--	0.25
		4D	1	1	--	--	0.55
Subtotals:			8	8	--	--	16.46
	6	1E1	3	3	-	--	1.35
		1E2	3	3	--	--	0.21
		1I	2	2	--	--	0.32
Subtotals:			8	8	--	--	1.88

Table 25 (Cont'd)

	Profile Number	Code Number	Total Motors Per Code	Power (kW)			Total Power Per Code (kW)
				Below 1	1 - 10	Above 10	
	7	1E1	6	6	--	--	4,48
		1E2	5	5	--	--	0.93
		1I	2	2	--	--	0.17
		4D	1	1	--	--	0.37
Subtotals:			14	14	--	--	5.95
	8	1H	1	1	--	--	0.37
		1K	11	11	--	--	2.18
Subtotals:			12	12	--	--	2.55
	9	1E1	4	4	--	--	1.00
		1E2	1	1	--	--	0.047
		1H	1	1	--	--	0.37
		4D	1	1	--	--	0.37
Subtotals:			7	7	--	--	1.787
	11	1B	2	2	--	--	0.74
		1E1	40	22	14	4	112.11
		1H	10	2	7	1	32.30
		1F	3	3	--	--	1.65
		1E2	2	2	--	--	0.96
Subtotals:			57	31	21	5	147.76
	13	1K	2	2	--	--	0.206
Subtotals:			2	2	--	--	0.206
	16	--	--	--	--	--	--
Subtotals:			--	--	--	--	--
	17	1E1	5	5	--	--	3.48
		1E2	1	1	--	--	0.09
		1H	1	1	--	--	0.76
		4D	2	2	--	--	1.10
Subtotals:			9	9	--	--	5.43

Table 25 (Cont'd)

	Profile Number	Code Number	Total Motors Per Code	Power (kW)			Total Power Per Code (kW)
				Below 1	1 - 10	Above 10	
	18	1A	2	2	--	--	0.25
		1E1	5	5	--	--	2.41
		1E2	2	2	--	--	0.17
		1I	2	--	2	--	5.20
Subtotals:			11	9	2	--	8.03
	20	--	--	--	--	--	--
Subtotals:			--	--	--	--	--
	21	1H	1	--	--	--	--
		1K	6	--	6	--	16.40
Subtotals:			6	--	6	--	16.40
	23	1E2	1	1	--	--	0.12
		1I	3	--	3	--	4.4
Subtotals:			4	1	3	--	4.52
	25	1E1	3	3	--	--	1.11
		1H	1	--	1	--	1.4
		1I	1	1	--	--	--
Subtotals:			5	4	1	--	2.51
	26	1E2	3	3	--	--	0.28
Subtotals:			3	3	--	--	0.28
	27	--	--	--	--	--	--
Subtotals:			--	--	--	--	--
	28	1K	4	4	--	--	0.52
Subtotals:			4	4	--	--	0.52
	30	1H	2	1	1	--	4.76
		1K	11	9	2	--	10.62
Subtotals:			13	10	3	--	15.38

Table 25 (Cont'd)

	Profile Number	Code Number	Total Motors Per Code	Power (kW) Below 1	Power (kW) 1 - 10	Power (kW) Above 10	Total Power Per Code (kW)
	31	--	--	--	--	--	--
Subtotals:			--	--	--	--	--
	33	1K	1	1	--	--	0.075
Subtotals:			1	1	--	--	0.075
	35	1E1	22	22	--	--	0.96
		1E2	2	2	--	--	0.96
		1G	9	2	7	--	71.80
		1H	3	2	1	--	2.50
		1I	1	1	--	--	1.30
Subtotals:			37	29	8	--	79.94
	36	1E1	3	1	--	--	0.075
		1E2	2	--	--	--	--
		1H	1	1	--	--	0.25
Subtotals:			6	2	--	--	0.325
	37	--	--	--	--	--	--
Subtotals:			--	--	--	--	--
	38	1E1	4	3	--	--	0.31
		1E2	3	2	--	--	0.095
		1G	1	--	--	1	11.00
		1H	2	2	--	--	1.32
		1I	2	2	--	--	0.32
Subtotals:			12	9	--	1	13.045
	39	--	--	--	--	--	--
Subtotals:			--	--	--	--	--
	40	--	--	--	--	--	--
Subtotals:			--	--	--	--	--

Table 25 (Cont'd)

	Profile Number	Code Number	Total Motors Per Code	Power (kW)			Total Power Per Code (kW)
				Below 1	1 - 10	Above 10	
	41	1K	2	2	--	--	0.04
Subtotals:			2	2	--	--	0.04
	42	--	--	--	--	--	--
Subtotals:			--	--	--	--	--
	44	--	--	--	--	--	--
Subtotals:			--	--	--	--	--
	46	1E1	3	3	--	--	1.37
		1E2	1	1	--	--	0.047
		1I	1	--	1	--	3.00
Subtotals:			5	4	1	--	4.417
	50	1K	1	1	--	--	0.047
		4B	5	--	3	2	40.50
Subtotals:			6	1	3	2	40.547
	51	3B	2	--	--	2	90.00
		4H	7	3	--	4	67.24
Subtotals:			9	3	--	6	157.24
	52	4H	2	--	--	2	37.00
Subtotals:			2	--	--	2	37.00
	56	1E1	4	2	2	--	16.80
		1H	1	--	1	--	2.6
		4A	2	1	--	1	28.02
		5E	1	--	1	--	6.50
Subtotals:			8	3	4	1	53.92
TOTALS:			278	194	59	19	758.48

Table 26

Motors Surveyed at Hohenfels by Profile, Application, and Power

	Profile Number	Code Number	Total Motors Per Code	Power (kW) Below 1	1 - 10	Above 10	Total Power (kW)
	0	1K	1	1	--	--	0.11
		4G	5	1	--	4	60.11
Subtotals:			6	2	--	4	60.22
	1	1A	1	--	1	--	2.20
		1E1	8	8	--	--	1.36
Subtotals:			9	8	1	--	3.56
	2	1E1	1	1	--	--	0.07
		1K	1	1	--	--	0.075
		4B	1	--	1	--	5.50
Subtotals:			3	2	1	--	5.645
	3	1M	2	--	2	--	3.00
		3G	1	--	1	--	4.00
		3H	1	--	1	--	3.00
		4C	2	2	--	--	0.16
		5C	2	--	2	--	9.20
Subtotals:			8	2	6	--	19.36
	4	1E1	1	1	--	--	0.34
		1H	1	1	--	--	0.25
Subtotals:			2	2	--	--	0.59
	5	1E1	6	6	--	--	1.18
		1E2	4	4	--	--	0.60
		1H	1	1	--	--	0.76
Subtotals:			11	11	--	--	2.54
	6	1K	2	2	--	--	0.68
		4C	3	3	--	--	0.72
		5A	1	1	--	--	0.017
Subtotals:			6	6	--	--	1.417

Table 26 (Cont'd)

	Profile Number	Code Number	Total Motors Per code	Power (kW) Below 1	1 - 10	Above 10	Total Power (kW)
	7	1B	1	--	1	--	1.1
		1E1	11	7	3	--	15.80
		1E2	3	2	--	--	0.15
		1H	2	1	1	--	5.20
Subtotals:			17	10	5	--	22.25
	8	1A	1	1	--	--	0.37
		1D	6	2	4	--	14.60
		1E1	19	9	9	--	31.48
		1E2	2	2	--	--	0.16
		1G	1	--	1	--	1.10
		1H	1	--	1	--	2.20
		1I	3	--	3	--	12.90
		1K	6	6	--	--	0.97
		3E	1	--	1	--	2.20
		5B	1	--	1	--	4.00
		5D	1	1	--	--	0.05
Subtotals:			42	21	20	--	70.03
	10	1E1	1	--	1	--	1.10
		1E2	1	1	--	--	0.02
		1H	1	1	--	--	0.76
		1I	1	--	--	--	--.--
		2A	4	--	2	--	4.80
		2B	2	--	--	--	--.--
		2C	5	--	--	--	--.--
		3G	2	--	2	--	1.50
		5A	2	2	--	--	0.05
Subtotals:			19	4	5	--	8.23

Table 26 (Cont'd)

	Profile Number	Code Number	Total Motors Per code	Power (kW) Below 1	1 - 10	Above 10	Total Power (kW)
	11	1A	2	--	--	2	22.90
		1C	11	3	8	--	17.95
		1E1	18	5	11	1	53.50
		1E2	8	4	2	--	3.31
		1I	23	6	12	18	44.64
		1B	2	--	2	--	15.00
		1D	7	--	7	--	6.42
		1G	2	--	2	--	4.20
		1H	1	1	--	--	0.10
		5A	3	3	--	--	0.54
Subtotals:			75	22	44	20	167.66
	12	--	--	--	--	--	--
Subtotals:			--	--	--	--	--
	15	2D	1	--	1	--	3.00
Subtotals:			1	--	1	--	3.00
	16	4I	9	--	2	7	473.00
		4I1	3	3	--	--	1.11
		4I2	1	--	1	--	2.20
		4D	1	1	--	--	0.50
		4E	1	--	1	--	1.10
		4F	1	--	1	--	4.04
		4H	1	--	1	--	5.00
		5A	2	2	--	--	0.55
Subtotals:			10	6	6	7	487.50
	17	1E1	1	1	--	--	0.18
		1H	1	1	--	--	0.24
Subtotals:			2	2	--	--	0.42

Table 26 (Cont'd)

	Profile Number	Code Number	Total Motors Per code	Power (kW) Below 1	1 - 10	Above 10	Total Power (kW)
	23	1M	10	5	5	--	15.19
		4C	1	1	--	--	0.065
Subtotals:			11	6	5	--	15.26
	27	1K	2	2	--	--	0.23
		1M	2	2	--	--	4.70
Subtotals:			4	4	--	--	4.93
	32	1K	2	2	--	--	0.02
Subtotals:			2	2	--	--	0.02
	35	1E1	9	9	--	--	3.11
		1H	1	1	--	--	0.76
		1M	1	--	1	--	5.00
		1E2	2	2	--	--	0.28
		1F	2	2	--	--	0.12
		1G	7	2	5	--	42.20
		1H	2	2	--	--	1.52
		4D	1	1	--	--	0.85
Subtotals:			25	19	6	--	53.85
	37	--	--	--	--	--	--
Subtotals:		--	--	--	--	--	--
	39	--	--	--	--	--	--
Subtotals:		--	--	--	--	--	--
	44	--	--	--	--	--	--
Subtotals:		--	--	--	--	--	--
	45	5C	5	--	5	--	55.00
Subtotals:			5	--	5	--	55.00

Table 26 (Cont'd)

	Profile Number	Code Number	Total Motors Per code	Power (kW) Below 1	1 - 10	Above 10	Total Power (kW)
	51	4B	1	--	--	1	13.00
Subtotals:			1	--	--	1	13.00
	52	1E1	1	1	--	--	0.45
		1I	2	2		--	0.32
		4C	4	2	[illegible]	--	4.54
Subtotals:			7	5	2	--	5.31
TOTALS:			275	134	107	31	999.78

Table 27

Motors Surveyed at Grafenwöhr by Application and Phase

Code Number	Total Motors Per Code	Phase 10	Phase 30	Both	Multispeed
1A	4	--	3	--	--
1B	2	--	2	--	--
1C	--	--	--	--	--
1D	--	--	--	--	--
1E1	112	--	106	6	35
1E2	31	22	3	6	13
1F1	3	--	3	--	--
1G	10	--	10	--	--
1H	26	7	19	--	--
1I	22	5	17	--	--
1J	--	--	--	--	--
1K	56	10	39	7	20
1L	--	--	--	--	--
1M	3	--	3	--	--
2A	--	--	--	--	--
2B	--	--	--	--	--
2C	--	--	--	--	--
2D	1	--	1	--	--
2E	--	--	--	--	--
2F	--	--	--	--	--
3A	--	--	--	--	--
3B	2	--	2	--	--
3C	--	--	--	--	--
3D	--	--	--	--	--
3E	--	--	--	--	--
3F	--	--	--	--	--
3G	5	--	5	--	--
3H	1	--	1	--	--
4A	2	--	2	--	--
4B	5	--	5	--	--
4C	2	--	2	--	--
4D	5	2	3	--	--
4E	--	--	--	--	--
4F	2	--	2	--	--
4G	2	--	2	--	--
4H	9	2	7	--	2
4I1	--	--	--	--	--
4I2	--	--	--	--	--
5A	--	--	--	--	--
5B	--	--	--	--	--
5C	--	--	--	--	--
5D	2	--	2	--	--
5E	1	--	1	--	--

Table 28

Motors Surveyed at Hohenfels by Application and Phase

Code Number	Total Motors Per Code	Phase 10	Phase 30	Both	Multispeed
1A	2	1	1	--	--
1B	3	--	3	--	--
1C	11	--	11	--	--
1D	13	--	13	--	--
1E1	75	-1	71	3	21
1E2	22	13	6	3	6
1F1	2	--	2	--	--
1G	10	--	10	--	--
1H	12	3	9	--	--
1I	27	3	24	--	--
1J	--	--	--	--	--
1K	--	--	--	--	--
1L	--	--	--	--	--
1M	12	2	10	--	--
2A	4	--	4	--	--
2B	2	--	2	--	--
2C	5	--	5	--	--
2D	--	--	--	--	--
2E	--	--	--	--	--
2F	--	--	--	--	--
3A	--	--	--	--	--
3B	--	--	--	--	--
3C	--	--	--	--	--
3D	--	--	--	--	--
3E	1	--	1	--	--
3F	--	--	--	--	--
3G	--	--	--	--	--
3H	1	--	1	--	--
4A	--	--	--	--	--
4B	1	--	1	--	--
4C	10	-2	8	--	2
4D	2	--	2	--	--
4E	1	--	1	--	--
4F	1	--	1	--	--
4G	5	--	5	--	--
4H	1	--	1	--	--
4I1	12	--	12	--	--
4I2	1	--	1	--	--
5A	8	2	6	--	--
5B	1	1	--	--	--
5C	7	--	7	--	--
5D	1	--	1	--	--
5E	--	--	--	--	--

Table 29

Motors Surveyed at Grafenwöhr by Application and Power

Code Number	Power (kW) Below 1	1 -10	Above 10
1A	1	1	1
1B	1	--	--
1C	--	--	--
1D	--	--	--
1E1	88	20	4
1E2	27	3	1
1F	3	--	--
1G	2	7	1
1H	7	18	1
1I	14	8	--
1J	--	--	--
1K	48	8	--
1L	--	--	--
1M	--	3	--
2A	--	--	--
2B	--	--	--
2C	--	--	--
2D	--	1	--
2E	--	--	--
2F	--	--	--
3A	--	--	--
3B	--	--	2
3C	--	--	--
3D	--	--	--
3E	--	--	--
3F	--	--	--
3G	--	5	--
3H	1	--	--
4A	1	--	1
4B	--	3	2
4C	--	--	2
4D	5	--	--
4E	--	--	--
4F	1	1	--
4G	2	--	--
4H	3	--	6
4I1	--	--	--
4I2	--	--	--
5A	--	--	--
5B	--	--	--
5C	--	--	--
5D	2	--	--
5E	--	1	--

Table 30

Motors Surveyed at Hohenfels by Application and Power

Code Number	Power (kW) Below 1	1 - 10	Above 10 kW
1A	1	--	1
1B	--	3	--
1C	3	8	--
1D	4	9	--
1E1	47	27	1
1E2	20	2	--
1F	2	--	--
1G	2	8	--
1H	8	4	--
1I	6	21	--
1J	--	--	--
1K	--	--	--
1L	--	--	--
1M	5	7	--
2A	--	4	--
2B	2	--	--
2C	5	--	--
2D	--	--	--
2E	--	--	--
2F	--	--	--
3A	--	--	--
3B	--	--	--
3C	--	--	--
3D	--	--	--
3E	--	1	--
3F	--	--	--
3G	--	--	--
3H	--	1	--
4A	--	--	--
4B	--	--	1
4C	8	2	--
4D	2	--	--
4E	--	1	--
4F	--	1	--
4G	1	--	4
4H	--	1	--
4I1	3	2	7
4I2	--	1	--
5A	8	--	--
5B	1	--	--
5C	--	7	--
5D	1	--	--
5E	--	--	--

Total Population Summary

As indicated in Table 31, 81 buildings were surveyed at Grafenwöhr and 47 were surveyed at Hohenfels. At each base, about one-third of the buildings surveyed contained no motors. Although less than 10 percent of the buildings at each base were surveyed, 19.2 and 23.0 percent of the total building area at Grafenwöhr and Hohenfels, respectively, was surveyed.

By examining the portion of audited area within each building category, the projected number of motors and kilowatt load were estimated for Grafenwöhr, Hohenfels, and both sites combined in Tables 22 through 24, respectively. These numbers indicate an estimated total motor population as follows:

- 685 motors at Grafenwöhr
- 670 motors at Hohenfels.

Because of the small portion of area audited in some building categories, these estimates must be viewed with caution. Several building categories (used synonymously with "profile category") received no audits. Most of these unaudited categories are expected to contain few, if any, sizable motor loads. Two exceptions are categories 47, "Water Well" and 44, "Wash Facility" in which significant motor loads are known to exist.

From an examination of Table 24, the building categories considered most intensive in motor loads are:

BC No.	Bldg Category (BC) Description
8	*Dining/Cafeteria/Snack Bar*
51	Sewage Treatment Plant
11	Heating Plant
20	Service Station
7	Troop Housing
35	Gymnasium/Recreational Building
43	Detached Lavatory
*44	Wash Facility (Vehicle)

Note: motors listed in Table 24 under the category "0 NOT ASSIGNED" were determined to belong mostly to category 44, "Wash Facility."

Table 31

Surveyed Buildings With Motors

Installation	Total No. of Bldgs	Buildings Surveyed	Surveyed w/ Motors	Surveyed w/o Motors	Total Motors
Grafenwöhr	948	81	54	27	271
Hohenfels	818	47	33	14	262

Of the categories listed above, sewage plants and heating plants could be expected to have major motor loads. The loads found in dining, troop housing, and detached lavatory areas were less than expected and should be noted with some caution because of the limited area comprising the basis for estimating the entire profile (note the "Multiply" number in Table 24). From the number of motors actually audited (not projected), the heating plants, gymnasium/recreational buildings, and dining/cafeteria categories were the top three motor locations and comprised more than 40 percent of the audited motors at Grafenwöhr and Hohenfels combined.

Motor Applications

As can be observed in Table 32, most motors (over 75 percent) are used in HVAC applications. About 10 percent are used in pumping applications for hot and cold water and sewage treatment. In the refrigeration category, 12 motors were found at Hohenfels but none at Grafenwöhr. The Grafenwöhr building list did not indicate the existence of a cold (food) storage facility at Grafenwöhr. Therefore, the refrigeration category in Table 32 is likely underrepresented. From Table 32, although most of the motors are in the HVAC category, the pumps (non-HVAC) category constitutes more than 45 percent of the total kilowatts compared with 40 percent for the HVAC category. Therefore, a closer look at both HVAC and pumps (non-HVAC) is needed.

Table 33 gives a more detailed breakdown of the HVAC category. Within this category, pumps and fans comprise 46 and 42 percent, respectively, of the total kilowatts. Most of the pump kilowatts are listed as being in the close-coupled configuration. With almost as much kilowatt load but with many fewer motors, fan loads are mostly listed as belt-drive configurations. These configurations could be significant when determining the feasibility of replacing an existing motor with a more efficient or more properly sized motor. Motors that are part of an integral unit cannot be readily replaced without considering the entire application.

Table 32

Number of Motors Serving Different Applications

Application	Number of Motors: Grafenwöhr	Hohenfels	Total	Total kW
HVAC	242	206	448	707
Refrigeration	0	12	12	10
Air compressors (non-HVAC)	7	4	11	120
Pumps (non-HVAC)	27	35	62	857
Other motors	3	17	20	62
	279	274	553	1756

Table 33

Motor Distribution in HVAC Applications

HVAC Application	Code	Number of Motors Grafenwöhr	Hohenfels	Total Power (kW)
Central Heat				
Air compressor belt drive	A	2	4	24.82
Air compressor close-coup	B	2	3	16.84
Conveyors belt drive	C	0	11	17.95
Conveyors close-coup	D	0	13	21.02
Pump close-coup one phase	E1	103	71	261.73
Pump close-coup three phase	E2	9	5	26.08
Pump close-coup one-third phase	E1/E2	23	16	2.67
Pump independent motor	F	3	2	1.77
Fan belt drive	G	10	10	147.00
Fan direct drive	H	26	12	62.16
Fan oil burner	I	22	29	86.01
Fan gas burner	J	0	0	--
Local Heat				
Pump independent motor	K	43	14	32.12
Pump close coup	L	0	0	--
Fan	M	0	0	700.17
TOTAL		242	206	700.17
Summary				
Compressors		4	7	41.66
Pumps		181	124	324.37
Fans		58	51	295.17
Conveyors		0	24	238.97
TOTAL		242	206	700.17

Motor Size Distribution Summary

Motor power requirement or size is another important variable. Retrofitting or replacing several large motors may be more cost-effective than taking similar action on many small motors. Table 34 indicates the number of various size motors found. It is not surprising that, at both installations, more than half of the motors are in the small (under 1 kW) motor group. However, this means that a significant number, 31 percent at Grafenwöhr and 48 percent at Hohenfels, are larger (> 1 kW), which means potentially greater savings if conservation techniques can be found.

Manufacturer's Information Review

The original objective in collecting manufacturer's information was to compare the data on their latest, most efficient motors with the models found during the field survey. The difference between field conditions and the manufacturer's most efficient equipment could indicate the potential for improvement. Several circumstances (discussed below) prevented complete success in realizing this objective.

Overview

Electric motors are produced in a variety of shapes and for thousands of different applications. The primary function of an electric motor is to convert electrical energy into rotating shaft energy. A typical electric motor consists of a stator (field) assembly, a rotor (armature) assembly, a shaft, and other miscellaneous enclosure components including bearings, cooling fan, and other small mechanical and electrical subassemblies. The stator is fixed within the enclosure and the rotor is mounted on the shaft which is centered concentrically within the stator. Variations in these typical components are used to classify motors. For instance, the enclosure may be complete, partially open, or totally open with only a skeleton to support the motor components.

Table 34

Motor Power Distribution

	Percent of Motors	
Category, (kW)	**Grafenwöhr**	**Hohenfels**
0.0 - 0.5	50.0	39.0
0.51 - 1.0	18.7	12.0
Subtotal, 0-1	68.7	51.0
1.1 - 2.0	8.2	17.0
2.1 - 3.0	7.8	10.8
3.1 - 4.0	3.0	5.0
4.1 - 5.0	1.1	1.5
5.1 - 10.0	3.7	7.7
Subtotal, 1-10	23.8	40.7
10.1 - 20.0	5.2	3.9
20.1 - 50.0	1.9	0.4
50.1 -100.0	0.4	2.7
Subtotal, 10-100	7.5	7.0

The motor shaft rotates when electrical current in the motor windings produces a torque on the rotor in a single direction. Therefore, an electric motor must consist of at least two sets of windings which are embedded or wound on slots in iron cores composed of stacks of thin, laminated electrical grade steel. The torque produced on the rotor must be great enough to overcome the inertia of the load on the motor. The electrical current used to excite either or both of the windings can be alternating (a.c.) or direct current (d.c.).

Motors can be further classified as synchronous, d.c., induction, and a.c. series motors. In a synchronous motor, alternating current is applied to one winding armature and direct current to the other field. Typically, direct current is applied to the windings placed on the rotor. In a d.c. motor, direct current is applied to both the stator and rotor windings. In an a.c. series motor, alternating current is applied to both windings which are connected in series. Finally, in an induction motor, alternating current is applied by induction to the rotor winding and directly to the stator windings. This study focused specifically on a.c. motors since these are the more prevalent type used.

Within the three major a.c. motor groups defined above (synchronous, induction, and a.c. series), several other subcategories exist. These subcategories can be defined by various physical and performance characteristics such as size, speed, application, electrical type, operating environment and enclosure. In the United States, the National Electrical Manufacturers Association (NEMA) has adopted definitions to describe motor subcategories based on these physical and performance characteristics. A different set of standards and regulations applies to motors built outside the United States. In Europe, electrical motors typically conform to International Electrotechnical Commission (IEC) standards. Rotating electrical motor construction configurations are further defined by DIN IEC 34-7 Code 1 as shown in Figure 60. Standards and regulations that govern electrical motors in Europe are shown in Table 35. In addition to these criteria, electrical motors are rated by voltage, frequency, power, speed, dimensions, and tested performance. Performance criteria include standardized testing, torque characteristics, current levels, and temperature limitations. The various design types and performance parameters produce hundreds of different types of motors.

Motor Efficiency

Efficiency losses in electric motors can be classified as intrinsic and extrinsic losses. Intrinsic losses determine the degree to which a motor transforms electrical energy into mechanical energy and can be affected only by motor design changes. Extrinsic losses are caused by operational conditions such as voltage or speed control devices that adjust a motor's peak power to load conditions. In general, motor efficiency can be defined as:

$$\text{Efficiency} = 1 - ((\text{Input} - \text{Output})/\text{Input})$$

or:

$$1 - (\text{Losses}/\text{Input})$$

or:

$$(\text{Output}/(\text{Output} + \text{Losses})) \times 100\%$$

Intrinsic electric motor efficiency losses can be divided into no-load and load losses. No-load losses are inherent in the motor design and occur as soon as the motor is energized (not under load). These losses are relatively constant, regardless of load. Load losses that vary with load account for most of the efficiency losses. Load losses can be divided into four categories: stray, core, resistance as I^2R (where I = current and R = resistance), and friction and windage losses. Figure 56 presents a breakdown of the losses for a typical 25-HP standard efficiency motor.

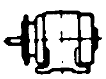
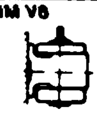
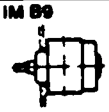
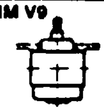
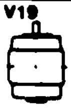
IM B3 	2 end shields, with feet, free shaft extension, mounting on existing base	IM V1 	2 end shields, without feet, free shaft extension pointing downwards, mounting flange A at driving end near bearing, bottom-flange-mounting
IM B35 	2 end shields, with feet, free shaft extension, mounting flange A at driving end near bearing, mounting on existing base, for flange-mounting	IM V15 	2 end shields, with feet, free shaft extension pointing downwards, flange A or C at driving end near bearing, wall-mounting
IM B34 	2 end shields, with feet, free shaft extension, mounting flange C at driving end near bearing, mounting on existing base, for flange-mounting	IM V3 	2 end shields, without feet, free shaft extension pointing upwards mounting flange A at driving end near bearing, overhead flange-mounting
IM B5 	2 end shields, without feet, free shaft extension, mounting flange A at driving end near bearing, flange-mounting	IM V36 	2 end shields, with feet, free shaft extension pointing upwards, mounting flange A at driving end near bearing, wall mounting
IM B6 	2 end shields, with feet, free shaft extension, type of construction IM B3, if required, end shields rotated through 90° wall mounting feet LH as seen from the driving end	IM V5 	2 end shields, with feet free shaft extension pointing downwards, wall-mounting
IM B7 	2 end shields, with feet, free shaft extension, type of construction IM B3, if required end shields rotated through 90° wall-mounting feet RH as seen from driving end	IM V6 	2 end shields, with feet free shaft extension pointing upwards, wall mounting
IM B8 	2 end shields, with feet, free shaft extension, type of construction IM B3, if required, end shields rotated through 180°, ceiling-mounting	IM V8 	1 end shield, without feet, free shaft extension pointing downwards, type of construction IM V1 or IM V18 without end shield (and without bearing) at the driving end, face mounting at the driving end
IM B9 	1 end shield, without feet, free shaft extension, type of construction IM B5 or IM B14 without end shield (also without bearing) at the driving end, face mounting	IM V9 	1 end shield, without feet, free shaft extension pointing upwards, type of construction IM V3 or IM V19 without shield (and without bearing) at the driving end, face-mounting at the driving end
IM B14 	2 end shields, without feet, free shaft extension, mounting flange C at driving end near bearing, flange-mounting	IM V18 	2 end shields, without feet, free shaft extension pointing downwards, mounting flange C at driving end near bearing, flange-mounting
IM B15 	1 end shield, with feet, free shaft extension, type of construction IM B3 without end shield (also without bearing) at the driving end, mounting on existing base, face-mounting	IM V19 	2 end shields, without feet, free shaft extension pointing upwards, mounting flange C at driving end near bearing, flange-mounting

Figure 60. IEC-34-8 European Motor Classification.

Table 35

European Motor Standards

Standard	Title
Electrical	
IEC 34-1 VDE 0530, Part 1,	Rotating Electrical Machinery, Ratings and Standards
IEC 34-1 VDE 0530, Part 8 DIN 57 530, Part 8	Terminal Markings of Rotating Electrical Machines
IEC 85 VDE 0530, Part 1	Insulating Material
Mechanical	
IEC 72 DIN 42 673-Part 1	Dimension and Output Ratings Standard Dimensions and Relationship Frame Sizes - Output Ratings, Design 1M
B3 DIN 42 677-Part 1	Standard Dimensions and Relationship Frame Sizes - Output Ratings, Design 1M
B5	
IEC 34-5 DIN 40 050	Degree of Protection
DIN IEC 34-7 DIN 42 948 DIN 42 955	Types of Construction Mounting Flanges Tolerance of Mounting Flanges.

Other standards and regulations that may apply include:

Belgium	NBN	Canada	CSA
Denmark	DS	Netherlands	NEN
France	NF	Norway	NEK
Great Britain	BS	Sweden	SEN
Italy	CEI	Switzerland	SEV

As Figure 61 shows, the I^2R losses consist of both the stator and rotor I^2R losses. These losses can be defined as the heating losses caused by current flowing through the conductor resistance. This resistance varies inversely with the cross section and conductivity of the material. Conductor resistance

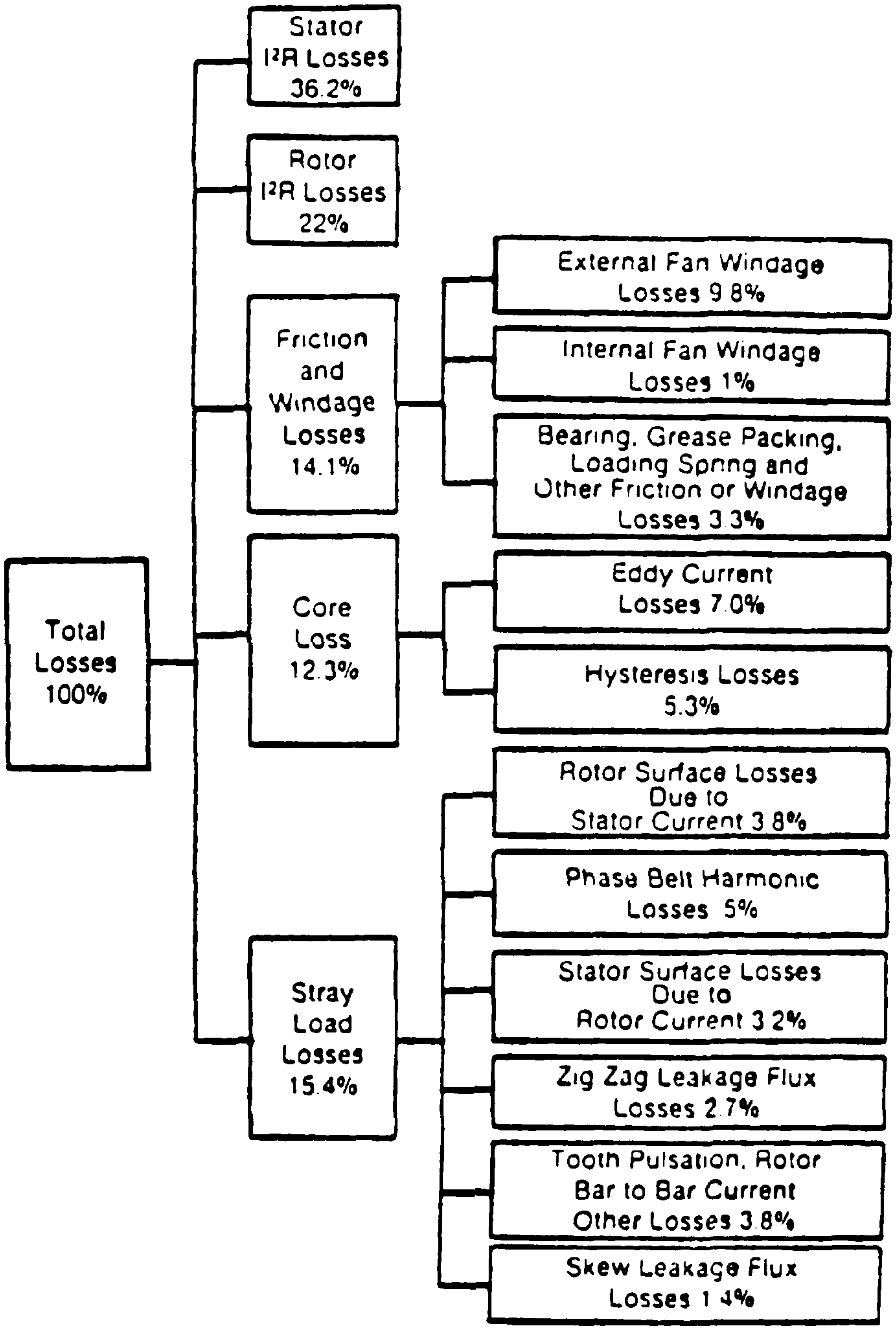


Figure 61. Intrinsic motor losses for a standard efficiency 25-HP motor.

is usually small at no-load condition but becomes a major component of losses at full load. These losses can be reduced by increasing the conductor cross section or by using higher conductivity material to reduce resistance. Motor current can also be reduced to lower I^2 R losses. This reduction can be accomplished by decreasing the magnetic component of current through a decrease in operating flux density or a reduced air gap.

Friction and windage losses are the result of bearing friction losses and fan wind resistance losses. These losses are relatively constant, regardless of load, due to the constant speed of the motor and its small variance with load. More efficient bearings and cooling fan designs are needed to reduce these losses.

Core losses consist of hysteresis losses and eddy currents and are constant regardless of load. These losses can be reduced by using different gauges and grades of steel. Better grades of steel reduce hysteresis through better core loss characteristics and thinner gauges of steel tend to reduce eddy currents caused by circulating currents within the core steel laminates. Finally, stray load losses are the result of several factors, including manufacturing design, air gap length, number of slots, slot geometry, leakage flux, and rotor slot insulation. These losses occur primarily in the rotor and stator iron and are roughly proportional to the current squared.

Power Factor

In addition to the intrinsic losses discussed above, the power factor also must be considered. In an a.c. circuit, power factor is defined as the ratio of active power (kW = volts x active current) to the total power (kVA = volts x total line current). "Active power" is the actual watts dissipated in the circuit or energy consumed in the circuit. "Total power" is the root mean square (RMS) voltage times the RMS current in the circuit, or the total power flowing in the circuit. In an electric motor, the magnetic flux must be established by the magnetizing components of motor current. This magnetizing current lags the active power current by 90 degrees and results in the reactive power requirements of the motor. The active power consists of the vector sum of the total power or resistive power and the pure reactive power as shown in Figure 62. Pure reactive power can be considered as borrowed power and true power as consumed power. Power factor is also equal to the cosine of the phase angle between the voltage and current of an a.c. circuit.

Currently, there is much interest in power factor and methods of improving power factor in a system. However, for most power consumers, power factor correction is not necessary because power factor is not a problem. A perfect power factor is 100 percent and results when the reactive power equals zero, apparent power is equal to the true power, and the quotient W/VA = 1. Power factor is reduced when the load becomes reactive. The two forms of reactance are inductive reactance, in which the current lags the voltage in the load, and capacitive reactance, in which the current leads the voltage applied to the load. Since inductive reactance is produced by coils and all mechanical work performed by electricity is done through magnetism, and since relatively few electrical loads exhibit capacitive reactance, all of the low power factor conditions found will be lagging or inductive. An exception to the above is a synchronous wound rotor electric motor operated with excessive d.c. excitation applied to the rotor. This motor will have a leading power factor and is often used in conjunction with other inductive loads to cancel some of the inductive reactance and improve the total power factor. This approach is feasible only for very large loads requiring a large, low-speed motor of several hundred horsepower or more.

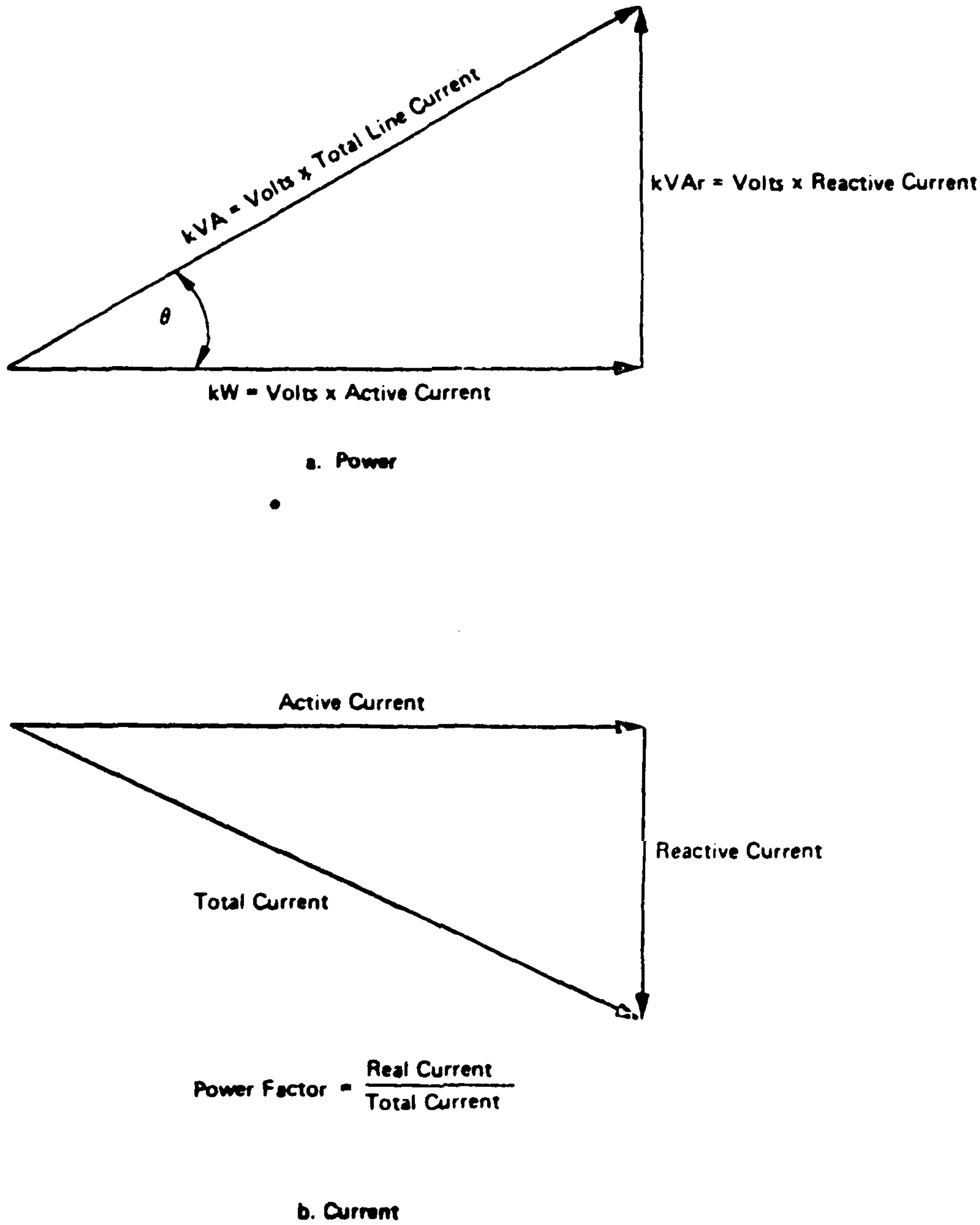


Figure 62. Power factor vector relationships.

System Efficiency

In addition to intrinsic motor efficiency losses, motor efficiency is also a function of load. As the load on the motor decreases, motor efficiency and power factor decrease. As an example, Figure 63 presents a typical performance curve for a 10-HP, four-pole, three- phase induction motor under constant torque operation (constant flux). As illustrated, the efficiency remains relatively constant with loads down to about 50 percent of full load and may actually increase somewhat. In contrast, power factor decreases

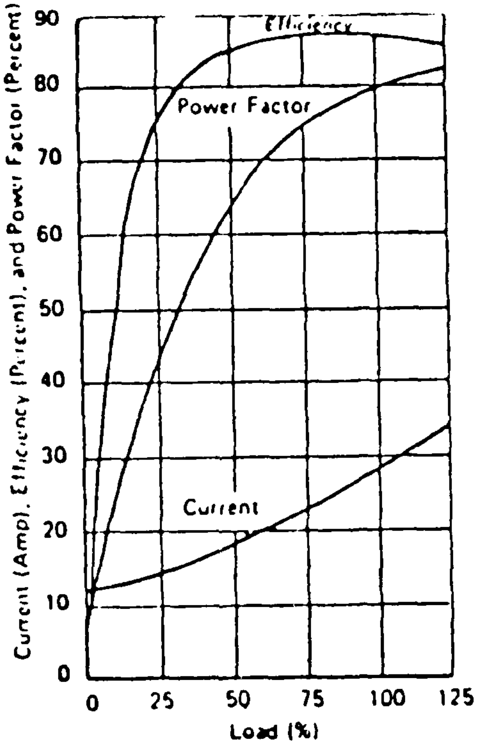


Figure 63. ***Performance curves for typical NEMA Design B 10-HP, 4-pole, three-phase industrial motor.***

more rapidly as a function of load. From these curves, it is clear why matching the motor to the load is important. However, numerous reasons make it difficult to accomplish this goal. In many cases, the load has not been defined adequately or is known to be extremely variable. Typical variable load situations occur in pumping and air-handling applications. These applications are very important since they represent the most prevalent uses of electric motors on military bases. For these common situations, variable-speed drives and voltage controllers can be used to increase efficiency at low loads.

Variable-frequency inverters provide efficient variable-speed motor operation of induction or synchronous motors. Use of inverters requires both frequency and voltage adjustment. Frequency control allows variation in the synchronous speed of the rotating flux wave while voltage control determines the amplitude of the flux wave. The current required to produce a given torque is independent of frequency for the operating conditions typically used with variable-speed drives. The basic concept of a variable-speed drive is to convert utility- supplied current into d.c. by means of either a controlled or uncontrolled rectifier followed by an inverter to provide three-phase voltage to the motor, adjustable in magnitude and frequency.

In the past, the most commonly used variable-frequency inverter motor drives included:

- Six-step voltage source inverter (VSI)
- Six-step current source inverter (CSI)
- Pulse-width-modulated voltage source inverter (PWM).

VSI and CSI inverters require a variable d.c. source to provide excitation control whereas the PWM inverter combines frequency and voltage control in a single converter.

In the VSI, the commutation circuits and gating signals are designed to produce a 180-degree conduction for each thyristor with three thyristors in the "on" state at all times. Reactive diodes used in the circuit provide reverse current paths. When a thyristor is gated on and the other thyristor in the same leg is switched off, the phase output terminal remains connected to one d.c. bus (negative or positive), regardless of the load current direction in that phase. The inverter input current must be capable of instantaneous change. For this reason, an inverter input capacitor is designed into the circuit. In the VSI circuit, there is always one line-to-line short circuit in which inductive load can exist. Only one line current is uniquely defined and three line-to-line voltages are uniquely related at all times. The short-circuit path provides the mechanism to supply the reactive current requirements for the reactive load excitation as would be found in an induction motor. The full cycle consists of six separate steps as shown in Figure 64.

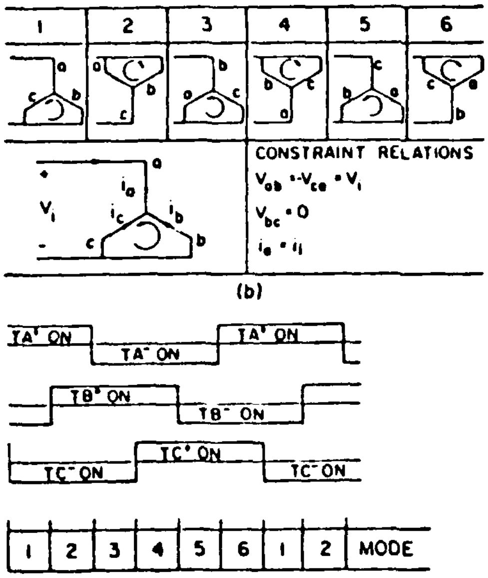
The concept behind the six-step CSI circuit involves having two thyristors "on" at all times and the gating signals and commutation circuit arranged to produce 120-degree conduction. Commutation is slower in this circuit arrangement than in the VSI concept. In some applications, this slower speed may affect performance. In the CSI circuit, all three output currents are uniquely related to the input current at all times. One output terminal is always open-circuited. This terminal's voltage is a function of the load. Instantaneous change in the inverter input voltage is typically accomplished using a large inductor. The full cycle consists of six separate conduction steps as are shown in Figure 64. As can be seen, exact duality exists between the VSI with a Y-connected load and the CSI inverter with a delta-connected load. The line-to-line short circuit of the VSI is the dual of the open circuit on one of the output lines in the CSI inverter. Similarly, the short-circuit current in the VSI inverter is a function of load, as is the open-circuit voltage of the CSI inverter.

The PWM inverter is a variation of the VSI inverter. All three output lines are connected to one of the input d.c. lines to yield a three-phase short circuit to load which controls output voltage. This arrangement allows a diode bridge to be used in place of controlled rectification since there is no need to control the inverter input voltage. The gating sequence and conduction modes for a simple PWM inverter are presented in Figure 64. The relative strengths and weaknesses of the basic inverter types are summarized in Table 36.

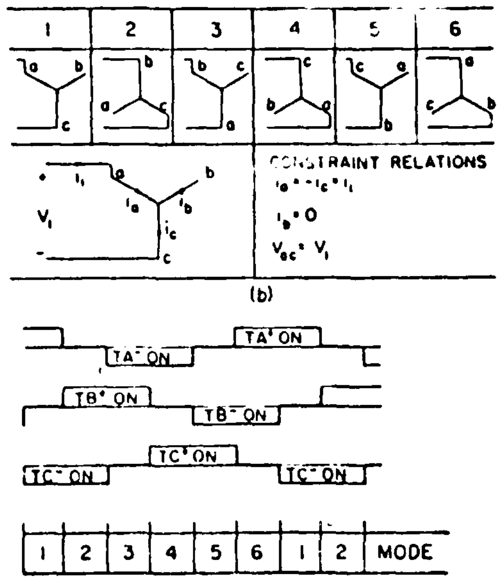
Review of Recent A.C. Motor and Control Developments

During the past 15 years, the overall average motor efficiency has improved nearly 3 to 4 percent due to advances in motor design and the market demand for more efficient motors. Most manufacturers have developed special high-efficiency motors that are typically another 3 to 4 percent more efficient than their standard efficiency motor products. Efficiency has been improved through several design changes, including:

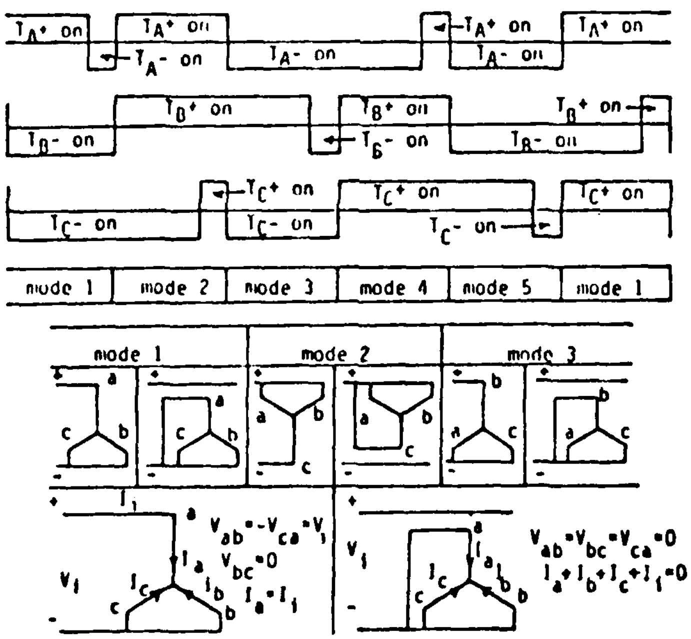
- Thinner lamination steels
- Improved lamination steel chemistry
- Longer stator and rotor cores
- More copper in stator slot
- Shorter end turns
- Larger stator slots with more copper



a) Six-Step VSI Circuit



b) Six-Step CSI Circuit



c) Simple PWM Circuit

Figure 64. Gating signals and conduction modes of adjustable speed drive controllers.

- Larger rotor slot with more aluminum
- Lower harmonic windings
- Smaller external cooling fans
- Air gap changes
- Copper bar rotor
- Higher conductivity rotor aluminum
- More efficient external cooling system
- Reduced internal windage
- Lower friction bearing system
- Better rotor insulation
- Grinding of the rotor surface
- Amorphous metallic glass laminations.

Table 36

Basic Inverter Strengths and Weaknesses

CRITERIA	VSI	CSI	PWM
Eff. at Low Speed	++	++	-
Input Power Factor (1)	-	-	+
Torque Pulsations	-	-	++
Stability	-	-	+
Multimotor Capability	+	-	+
Regeneration	-	++	-
Short Circuit Protection	-	++	-
Open Circuit Protection	+	-	+
Handle Undersized Loads	+	-	+
Handle Oversized Loads	-	+	-
Simplicity	+	+	-
Size and Weight	-	-	+
Thyristor Requirements		+	-

In most cases, these design and material improvements have resulted in more expensive motors. Depending on size, most manufacturers charge about 20 percent more for their high-efficiency motors. Nearly all motor manufacturers offer a high-efficiency motor product.

During the past 10 years, considerable progress has also been made in the area of a.c. adjustable drives. Recent advances include:

- Matched motor/drive performance characteristics designed for wider speed range

- Higher performance a.c. drive using vector technology and high- speed switching techniques, resulting in more dynamic performance

- Advances in high-powered power transistors which have replaced the SCR through the 1000-HP range

- Increased use of microprocessors, VLSI, and surface-mounted devices to reduce equipment size and cost

- Refinements in control algorithms.

These advances have produced more compact, reliable, and lower cost products. Figure 65 illustrates the relative advances in costs and sizes for a typical 20-HP a.c. controller since 1978. Typical installation and equipment costs for a.c. adjustable-speed drives for induction motors are shown in Figure 66 (in 1986 dollars) for the 7.5- to 50-HP range. Variability in cost is produced by different design configurations such as distances to the power source and the motor from the controller, requirements for bypass switching, and labor rates.

Summary of Manufacturer Information

Based on the field information gathered, a list of manufacturers who supplied equipment to Grafenwöhr and Hohenfels was compiled (Table 37). This list is composed of several different types of equipment vendors including those for pumps, air compressors, crushers, refrigeration units, and fans, as well as motors. USACERL sent each manufacturer a letter requesting product brochures and specification sheets for equipment found in the audit. In addition to the 68 foreign vendors, electric motor and variable-speed controller information was solicited from 16 U.S.-based manufacturers. A breakdown of the motors supplied by each manufacturer is given in Tables 38 and 39 for Grafenwöhr and Hohenfels, respectively.

Of the 68 foreign vendors, replies were received from 23 vendors. Thirteen of the 16 U.S. vendors also replied for a total of 39 responses from 84 inquiries. Manufacturers responding to the request are listed in Table 40.

Much of the information gathered from the manufacturers during this study consisted of general sales material or contained too little detail to evaluate specific motor performance relative to other similar motors in the catalogs received. Changes in design and model names/numbers also made it difficult in many cases to establish an exact match between nameplate model numbers and the models in the product brochures. Also contributing to the difficulty in matching nameplate and brochure information was the incompleteness and/or illegibility of some motor nameplates observed in the audit. Furthermore, it was rare--even in informative product brochures--for the manufacturers to supply efficiency curves for their entire motor line. This made it nearly impossible for USACERL to compare inventoried motors with the manufacturer's most efficient models. Performance information about specific motor models was available from the manufacturer in some cases for a fee.

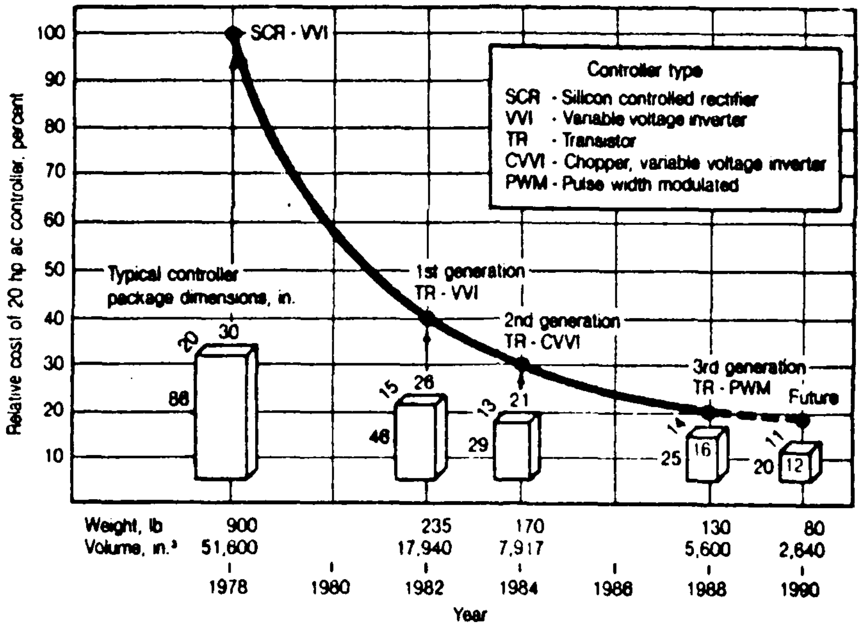


Figure 65. Progress in a.c. drive technology.

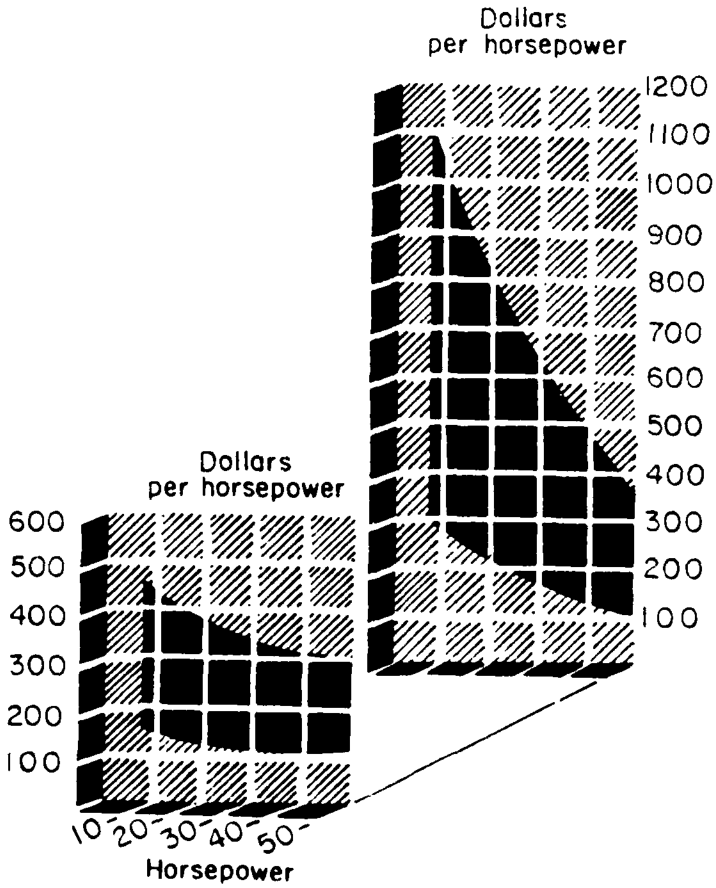


Figure 66. Costs of adjustable speed drives (1989 dollars).

Table 37

Manufacturers Supplying Equipment to Hohenfels and Grafenwöhr

Ervin Kuhnle GmbH
Porschester 45
7000 Stuttgart 40

Allweiler Pump Inc.
5410 Newport Dr. 40
Dept. LS
Rolling Meadows, NJ 60008

ASEA Control
One Odell Plaza
Yonkers, NJ 10701

Bauknecht Hausgerate GmbH
AM Wallgraben 99
Postf 80 03 43
7000 Stuttgart 80
West Germany

Ben Buchele Electro. GmbH
Popenreuther Str 49a
8500 Nurnberg - 90
West Germany

Buderus Aktiengesellschaft
Postf 12 20
6330 Wetzlar
West Germany

Centra-Burkle GmbH
Boblinger Str 17
Postf 11 64
7036 Schonaich
West Germany

Continental Electro. AG, Schorch
Brete Str 131
Postf 20 11 52
4050 Monchengladbach-2
West Germany

Century Electric Inc.
1831 Chestnut Street
St. Louis, MO 63166

AEG Corporation
Route 22 - Orr Drive
Somerville, NJ 08876

ATMA Antriebstechnik GmbH
Anton Richter WEGB
West Germany

BBC Brown Boveri Corporation
1462 Livingston Avenue
North Brushwick, NJ 08902

Beringer Hydraulik GmbH
CH 6345 Neuheim-Zue
Switzerland

Carl Bockwoldt GmbH & Co KG
Getriebemotorenwerk
Sehmsdorfer Str 43-53
Postf 12 80
2060 Bad Oldesloe
West Germany

Continental Electric Co, Inc.
325 E. Ferry Street
Neward, NJ 07105

Copeland Corp.
1675-T Campbell Road
Sidney OH 45365

Table 37 (Cont'd)

Dietz Motoren GmbH & Co KG
Elektromotorenfabrik
Eisenbahn-Str 67
Postf 11 20
7319 Dettingen Unter Teck
West Germany

Eberhard Bauer GmbH & Co
Verkaufsburo
P6,22,6800 Mannhein-1
West Germany

ELCO Elektronik GmbH
Alter Weg-1
5241 Niederdriesbach
West Germany

Elektro-Maschinen-Fertigung
Niedesheimer Str-18
6520 Worms-1
West Germany

Elektromotoren Werke
Karl Kaiser
Grobbeerenstr 164
1000 Berlin-48
West Germany

EMU Unterwasserpumpen GmbH
Heimgartenstr 1
Postf 3309
8670 HOF (SAALE)
West Germany

Ervin Halder KG Maschinenfabrik
Ervin-Halder-Str 5-7
Postf 209
7959 Achstetten 3
West Germany

Flaco Gerate GmbH
Isselhorster Str 377
4830 Gutersloh
West Germany

General Electric Company
777 Church Road
Elmhurst, IL 60126

Grundfos Pumpenfabrik GmbH
2362 WahlStedt
West Germany

Gustav Blecher GmbH & Co KG
Auf Der Weih
6348 Herborn 1
West Germany

Hawkar Siddeley Canada Inc.
Trenton Works Div
P.O. Box 130
Trenton,N S,Canada BOK1XO

Herbert Odenwald
Elektromotorenfabrik KG
Zur Kuppe 1
Postf 240
6427 Bad Salzschlirf
West Germany

Jung Pumpen GmbH
4802 Stainhagan
West Germany

Karl W. Muller
D-7300 Esslingen
Elektror
West Germany

Kaeser Compressoren GmbH
Carl-Keiser-Str 26
8630 Coburg, Bertelsdorf
West Germany

Table 37 (Cont'd)

Klein, Schanzlin & Becker AG
Geschaftsbereich Serienpumpen
Haus-Und Industrietechnik
Postfach 225
D-6710 Frankenthal (PFALZ)
West Germany

Landis & Gyr, Inc.
99-A Castleton Street
Pleasantville, NY 10570

Loher AG
Technisches Buro
GierkeZiele 16
1000 Berlin-10
West Germany

Magnetic Electromotoren GmbH
7867 Maulburg
West Germany

MAICO
D-7730 Schwenningen
West Germany

Marathon Electric
Wausau, Wisconsin 54401

Pumpen Mahn
85 Nurnberg
West Germany

Max Weishaupt GmbH
7858 Schwendi
West Germany

Ritz Pumpenfabrik GmbH & Co KG
7070 Schwabisch
Guiund
West Germany

Robatherm Warme-U Klimatechnik
D-8872 Burgau
West Germany

Robert Birkenbeul KG
05249 Hamm
7 Steg
West Germany

Ray-Wiesbaden-Werk
Schierstein
West Germany

Klimagerate
Luftungsgerat
West Germany

Schorch GmbH
Vertriebsburo
Donnerburgweg 3
3300 Braunschweig
West Germany

Schluter-Elektromotoren
Radolizeh
Bodensee
West Germany

SEW-Eurodrive GmbH & CO
Suddeutsche Electro.-Werke
Durlacher Str 5
7520 Bruchsal
West Germany

Table 37 (Cont'd)

The Trane Company 88 Golbey France	Theo Halter GmbH 6832 Hockenheim West Germany
Vem Veb Electromotoren Werke Thurm West Germany	Wilo Werke GmbH & CO 4600 Dortmund 30 Nortkirchenstrabe 100 West Germany
Ziehl-Abegg GmbH & CO KG Zeppelinstr 28 7118 Kunzelsau West Germany	Siemans AG Direktion (bbn 40 01869 0) Wittelsbacherplatz 2 8000 Munchen-2
Stephan Werke Hameln West Germany	Electra Bekum West Germany
Conz Hamburg West Germany	Beachte Co. West Germany
Ansaldo Genoa Italy	Auma
Wagner	Sever Subutica Yugoslavia
Rotex	Line Company
Limodor-F	Karcher Co. West Germany
Kabe	FFD Wein Austria

Table 38

Inventory of Equipment Supplied by Manufacturers to Grafenwöhr

---------Power,KW----------

Manufacturer		Model Number	Below 1		1-10 Power,KW	Above 10	TotalCodes
AEG	AM100MV4	-	-	1	11	1G	
	AM90SX2	-	1	-	1.5	1E1	
	CAM71NK4	1	-	-	0.37	1E1	
	CAM80KY4	1	-	-	0.55	1E1	
	EB117M40/4T	1	-	-	0.37	4D	
	EB95C36/2	1	-	-	0.11	1E2	
	EB95C65/2	1	-	-	0.25	1H	
	eAN100LAMZ8EX	1	-	-	0.95	1I	
ALLWEILIER		4AP71-2	2	-	-	1.10	1E1
ANSALDO		A1-C0811BA002	2	-	-	2.2	1I
ANTRIEBSTECHNIK		RF5.5/2-75BW	-	1	-	7.5	1E1
	A90L/4B-11S	-	1	-	1.5	1E1	
	R15/472	-	1	-	1.5	1E1	
ASEA	MT71A14F85-2	2	-	-	0.74	1E1	
	MT90L24-4	-	2	-	3.00	1E1	
	MT90S24-4	2	-	-	2.2	1E1	
	M180L	-	-	2	44	1E1	
	MBT160L	-	-	2	30	1E1	
BBC, BROWN BOVERI		EQU1000L4AG	-	-	1	15	1A
	531175	-	-	-	-	1A	
BEACHTE		NF1.1/4-1MW	-	-	-	-	3H
BEN NURNBERG		ADG94EX	-	1	-	3	4B
BERINGER-HYDRAULIK		132K28	-	-	1	28	4A
BLECHER-MOTOREN		ZK90L2	-	1	-	2.2	1I
BUDERUS		KZG160.2	-	2	-	5.2	1I
CENTURY ELECTRIC COMPANY		CS	-	-	-	-	1H
	DS	-	-	-	-	1H	
CONTINENTAL ELEKTROINDUSTRIE		A1053/4200L	-	-	2	90	3B
CONZ HAMBURG		eUM160L-4	-	-	1	12	4B
ELCO	7KD2-291	2	-	-	1.1	1H	

Table 38 (Cont'd)

	---------Power,KW---------					
Manufacturer	Model Number	Below 1		1-10 Power,KW	Above 10	Total Codes
ELECTROMOTOREN WERKE	AD13/4	2	-	-	1.6	1I
AD35/2	-	1	-	9	3G	
FLACO F LANDWEHR	A0-90L-283	-	1	-	2.2	3G
GENERAL ELECTRIC	5KC39RG256BU	-	-	-	-	1H
GRUNDFOS	UMC50-60	2	-	-	0.87	1K
UMS40-30F06	2	-	-	0.43	1E1	
UMS50-30F06	2	-	-	0.52	1E1	
UMS50-60F06	3	-	-	1.35	1E1	
UMS50-60F10	1	-	-	0.45	1E1	
UMSD-40-30F10	1	-	-	0.215	1E1	
UMSD40-30F16	2	-	-	0.43	1E1	
UMSD50-30F06	4	-	-	1.04	1E1	
UMSD50-60F06	4	-	-	1.8	1E1,1K	
UMSD50-60F10	4	-	-	1.8	1E1	
UMSD5010F06	2	-	-	0.9	1K	
UMSD65-60F06	2	-	-	1.16	1E1	
UMSD80-30F10	1	-	-	0.44	1E1	
UMSD80-60F06	2	-	-	1.96	1E1	
UP15-15NX25	2	-	-	0.064	1E2	
UP20-35	2	-	-	0.134	1E1	
UP25-30N	4	-	-	0.16	1E1,1K	
UP25-45NL	1	-	-	0.11	1E2	
UP40-75R	2	-	-	0.52	1K	
UPS-15-20X20	1	-	-	0.06	1K	
UPS50-120	1	-	-	0.98	1E1	
UPSD32-25	2	-	-	0.17	1E2	
UPSD32-35	6	-	-	0.51	1E2,1K	
UPSD32-45	1	-	-	0.09	1E2	
UPSD32-45F	8	-	-	0.72	1E1,1E2,4H	
UPSD40-60F06	2	-	-	0.64	1E2	
UPSD40-60F10	1	-	-	0.345	1E1	
UPSD40120	2	-	-	1.4	1K	
UPSD50-120-F06	4	-	-	3.92	1E1	
UPSD50-120F16	1	-	-	0.98	1E1	
MG80A4-19F100	1	-	-	0.55	1E1	
HALDER DT80B-2 ELECTROMOTOREN	-	1	-	1.1	1E1	
HAWKAR SIDDELEY	7B-VD250MUD7BT4	-	-	2	110	4C

Table 38 (Cont'd)

Manufacturer	---------Power,KW--------- Model Number	Below 1		1-10 Power,KW	Above 10	Total Codes
KAESER KCT60 KOMPRESSOREN	1	-	-	0.37	1B	
KARCHER	HDS1200EK-210	-	1	-	4.2	1E1
KSB LS71	1	-	-	0.55	4D	
LIMODOR	C	1	-	-	0.05	1I
LOHER & SOHNE	A160M2A-2	-	-	3	45	4H
A112MA-V8/4	-	2	-	7.4	1G	
A132MA-V8/4	-	3	-	20.40	1G	
AL100L2B-4	-	1	-	3	1I	
A160LA-V8/4	-	-	1	13	1G	
A160MA-V8/4	-	-	1	10	1G	
A180MA-V8/4	-	-	1	16	1G	
d3A132SC-4	-	1	-	5.5	4B	
eA132SA-4	-	1	-	5	1I	
MAICO EZR30/2-A	1	-	-	0.5	1I	
ERM25	1	-	-	0.26	1I	
MARATHON ELECTRIC	SCS	-	-	-	-	1I
MAX WEISHAUPT GmbH	DK3/115-2	-	1	-	4.5	1H
EC04-2	1	-	-	0.1	1H	
D132/150-2	-	-	1	12	1H	
DK07-2/1	2	-	-	1.52	1H	
DK08/09-2/1	-	2	-	2.8	1H	
DK08/90-2/2	-	1	-	1.4	1H	
DK2-2	-	6	-	15.60	1H	
DK3/115-2a	-	1	-	4	1H	
PUMPEN-MAHN	MG71B14F85	2	-	-	1.10	1E1
MG712A-14F85	1	-	-	0.37	1E1	
RITZ PUMPENFABRIK	K2510	-	1	-	3.95	1I
ROBATHERM WARME U - KLIMATECHNIK	RK25	1	1	-	1.85	1I
ROTEX PA-I1032	4	-	-	2.2	1F, 4D	
SCHLUTER-ELEKTROMOTOREN	AP90L-4	-	1	-	1.5	1E1

Table 38 (Cont'd)

Manufacturer	Model Number	--------Power,KW------- Below 1	1-10	Above 10	Power, KW	Total Codes
SIEMENS	1LA3083-2AA22-Z	-	1	-	1.1	1E1
	1LA3166-2AA40	-	-	1	18.5	4H
	1LA5131-2AA70	-	2	-	15.8	1E1
	1LAS107-4AA29-Z	-	3	-	6	1E1
	1LP3053-4AB992	1	-	-	0.07	4H
	OR8.9-4	2	-	-	0.27	5D
T-T ASEA	MT71A14F85-2	1	-	-	0.37	1E1
THEO HALTER GmbH	D718-2	1	-	-	0.55	1E1
TRANE 88-GOLBEY	4412-4181	1	-	-	0.25	1A
WAGNER DP1	-	-	-	-	4B	
WILO WERKE	DOP32/80V	5	-	-	0.48	1E1,1E2
	DOP40/100V	3	-	-	0.42	1E1
	D50	1	-	-	0.02	1E1
	P40/100r	1	-	-	0.164	1E1
	P40/160V	1	-	-	0.3	1E1
	P65/125r	2	-	-	1.08	1E1
	P80/125V	1	-	-	0.48	1E1
	RP25/100V	2	-	-	0.22	1E1
	RP25/80V	2	-	-	0.18	1E1
	TP80-1	4	-	-	1.92	1E1,1E2
	Z20	-	-	1	20	1E2
	Z25	2	-	-	0.115	1E1,1E2
	Z25T4	1	-	-	0.047	1E2
	Z40	2	-	-	0.56	1E1
	D65	1	-	-	0.075	1K
	DOP32/80r	2	-	-	0.206	1K
	DOP40/100A	4	-	-	0.52	1K
	DPA80/180-2.2/4	-	2	-	4.4	1K
	P40	2	-	-	0.15	1K
	P50-2	1	-	-	0.076	1E1,1E1
	P50/128V	2	-	-	0.37	1K
	TP30	2	-	-	0.04	1K
	D30	1	-	-	-	1E1,1E2
	D40	1	-	-	-	1E1,1E2
	P40-2	1	-	-	-	1E1
ZIEHL-ABEGG	2UW186.27-6/24	-	1	-	6.5	5E
	DAS350-4-4-8	2	-	-	0.32	1I
	DAS350-4-4	3	-	-	0.32	1I

Table 39

Inventory of Equipment Supplied by Manufacturer to Hohenfels

Manufacturer	Model Number	---------Power,KW--------- Below 1	1-10	Above 10	Power,KW	Total Codes
AEG	AM132SS2	-	1	-	5.5	1I
	AM90LX2	-	1	-	2.2	1H
	AMV132MR4/6	-	2	-	10.4	1I
	AN90LX2	-	2	-	4.4	1G
	CAM100LS2	-	3	-	9	1I
	CAM90LX2	-	2	-	6.6	1I
	NK43f-4	1	-	-	0.8	1M
ASEA,SWEDEN	MBT132M	-	1	-	7.5	1E1
ANTRIEBSTECHNIK	AB068503TF	-	1	-	3.7	5C
AUMA	MD56-2/45	1	-	-	0.18	5A
	MP56-2/60	1	-	-	0.37	5A
BBC,BROWN BOVERI	DU24	-	2	-	3.7	1A,3G
	QU180M2BG	-	-	1	22	1E1
	QU80M4BAT	2	-	-	1.5	1E1
	QU90S4AAT	-	3	-	3.3	1E1
	QUL4AAT	-	1	-	1.5	1E1
	DU 124	-	1	-	1.5	2A
BROWN-BROCKMEYER	PM	-	-	-	-	2A
BUDERUS	-	-	2	-	4.7	1M
CARL BOCKWOLDT	2-90S/4D	-	1	-	1.1	1D
	CB1-90/4DBRF	-	1	-	1.5	1D
	CB5/0-80K/40	1	-	-	0.55	1D
	CB771-100L/40	-	1	-	2.2	1C
	CBP-16M6D	-	1	-	9.2	1D
	CD3-100L/6D	-	1	-	1.5	1C
CENTRA-BORKLE,GmbH.	VMV23PNW40-50	1	-	-	0.025A	
CONTINENTAL ELECTRIC COMPANY	AC.SO.CAGEIND.	-	-	-	-	5C
COPELAMETIC,USA	-	-	-	-	-	2C
DIET2-MOTOREN,KG	FDR806/29	-	1	-	1.1	1G
	DR710/2p	1	-	-	0.37	4I1
DREIPHASEN DREHSTROM	A1C0901BA002	-	1	-	1.5	1M

Table 39 (Cont'd)

Manufacturer	Model Number	---------Power,KW--------- Below 1	1-10	Above 10	Power,KW	Total Codes
EBERHARD BAUER	D2A123HZ/309K	2	-	-	1.1	1C,1D
	DK841AH/200L	2	-	-	1.5	1C,1D
	DK924E/241	-	2	-	3	1C,1D
	DO741A/200L	1	-	-	0.75	1C
	G21-10/DK94-241	-	2	-	4.4	1C
	D044/141LS	1	-	-	0.11	4C
	D044E2/116S-MF	1	-	-	0.03	4C
	DO76EZ367200L	1	-	-	0.55	1E1
ELECTRA BECKUM	EBLP	-	1	-	3	3H
ELECTRO-MASCHINEN		GLF.80/2-3	-	1	-	- 2I
-FERTIGUNG	GLF90/2-2	-	1	-	8.2	1I
	GLF80/15	-	1	-	2.5	1I
	GLF900/2/3	-	1	-	7.5	1I
ELECTROMOTOREN WERKE,KASLER	AD13/4	-	-	-	-	1I
ELEKTRA BECKUM	381	-	1	-	2.2	3E
EMU GmbH HOF/SAALE		-	1	1	-	5.54D,4H
FFD WIEN	DPIOOLA/4	-	1	-	2.2	4I2
GENERAL ELECTRIC		KG	-	-	-	- 5C
GRUNDFOS	SP-70-18	-	-	1	52	4I
	UMS40-30F06	2	-	-	0.295	1E1,4C
	UMSD40-30F06	1	-	-	0.215	1E1
	UMSD50-60F06	2	-	-	0.9	1E1
	UMSD50-60F16	1	-	-	0.45	1E1
	UP203	1	-	-	0.09	1K
	UP25-45-NL	3	-	-	0.34	1E2
	UP4070R	1	-	-	0.14	1K
	UPD32-50	2	-	-	0.12	1E1
	UPS15-35X20	1	-	-	0.065	4C
	UPS15-45X20	1	-	-	0.08	4C
	UPS50-120-F16	1	-	-	0.98	1E1
	UPSD40-60F06	2	-	-	0.69	1E1
	VN10-60	-	-	1	75	4I

Table 39 (Cont'd)

Manufacturer	Model Number	---------Power,KW--------- Below 1		1-10	Above 10 Power,KW	Total	Codes
HALBERG	D-H0125X9	-	-	4	268	4I	
HAWKAR SIDDELEY	-	1	-	-	0.11	1K	
HERBERT ODENWALD		eDF71S/2		1	-	-	0.3IM
JARA ELETROMOTORES		112M780		-	1	-	3G
JUNG PUMPEN GmbH		-	1	--	-	0.85	4D
KABE	3-BEF803-2	1	-	-	0.09	1M	
	AED2/4CS	-	-	-	-	1I	
KAESER COMPRESSOREN	KCT150	-	1	-	1.1	1B	
	KC160	1	-	-	0.37	1A	
KARL W.MULLER	D-05	3	-	-	0.57	1I	
KLEIN, SCHANZLIN & BECKER	AP10001-4S	-	1	-	2.2	4C	
	DKN100.4-2.2	-	1	-	4.04	4F	
	AP100L-4S	-	1	-	2.2	4C	
KLIMAGERAT LUFTUNGSGERAT	VA-M-FE-VZ14-2R	-	1	-	3.5	1G	
KUELE STUTTGART ELECTROMOTOREN	U	KMER160L4		-	-	4	60G
LANDIS & GYR	-	1	-	-	0.017	5A	
LOHER GmbH	A112MA-V8/4	-	2	-	7.4	1G	
	A132MA-V8/4	-	1	-	6.8	1G	
	A132SA-V8/4	-	2	-	10	1G,1M	
	A160LA-V8/4	-	-	1	13	1G	
	A160MA-V8/4	-	1	-	10	1G	
MAGNETIC ELECTROMOTORON	SP30.4AD	3	-	-	0.54	5A	
MAICO	EK30/4	1	-	-	0.1	1M	
MAX WEISHAUPT	DK07-2/2	3	-	-	2.28	1H	
	EC04-2	1	-	-	0.1	1H	
	DK07-2/1	3	-	-	2.28	1H	

Table 39 (Cont'd)

Manufacturer	Model Number	Power, KW: Below 1	Power, KW: 1-10	Power, KW: Above 10	Total Power, KW	Codes
MAX WEISHAUPT	DK2-2	-	1	-	2.6	1H
	ECK07-2	1	-	-	0.25	1H
PUMPEN MAHN	ZAS850F	-	-	-	-	1E1
RAY-WIESBADEN-WERK	0EWA097JE009440	1	-	-	0.24	1H
ROBERT BIRKENBEUL	AP100L-4	-	1	-	5.5	5C
SCHORCH-WERKE	KAD37/4	-	1	-	3.3	2A
SEVER SUBOTICA	K80B2	-	1	-	1.1	1M
SEW EURODRIVE	R106DT132S-4	-	1	-	3.3	1C
	R86DT90L-1	-	1	-	1.5	1C
	R96D190S-4	-	1	-	1.1	1D
	R96DT90L-4	-	1	-	1.5	1C
	RF40DT90S4	-	4	-	4.4	1D
	SA5001710-4	1	-	-	0.37	1D
SIEMENS	1LA5131-2AA70	-	1	-	7.5	1M
STEPHAN-WERKE	FZBD044S	2	-	-	0.74	4I1
THEO HALTER GmbH	D100L-2	-	2	-	6	1E1
	D71A-2	1	-	-	0.37	1E1
	D90L-2	-	2	-	4.4	1E1
	DP1N112M-2	-	1	-	4	1E1
	D80B-1	-	1	-	1.1	1E1
TRANE CEM LEON	-	-	1	-	3	2D
ELECTROMOTOREN WERKE/GDR	KMER80G2	-	1	-	1.1	1M
WILO WERKE	100/160V	-	1	-	1.8	1E1
	D125	1	-	-	0.48	1E1
	D65	1	-	-	0.075	1E1,1E2
	DOP50/100r	3	-	-	1.02	1K,4C
	DOS50/100r	2	-	-	1.29	1E1
	DOS80/125rPN10	-	1	-	1.55	1E1
	DP/IP65/250/3/4	-	1	-	3	1E1
	P100/160V	-	1	-	1.1	1E1
	P40-1	2	-	-	0.15	1E1,1E2,1K
	P50-1	-	-	-	-	1E1
	P50/125V	2	-	-	0.36	1E1

Table 39 (Cont'd)

Manufacturer	Model Number	Power, KW: Below 1	1-10	Above 10	Total Power, KW	Codes
WILO WERKE	P50/125r	2	-	-	0.68	1E1,1K
	P50/160	-	-	-	-	1E1
	P50/160r	1	-	-	0.54	1E1
	P65/125V	1	-	-	0.54	1E1
	P80/250V	-	1	-	2.5	1E1
	RS 25	2	-	-	0.04	1E2
	RS23/60r	1	-	-	0.079	1E2
	RS25/60R	2	-	-	0.282	1E2
	RS25/60V	1	-	-	0.77	1E2
	RS40	1	-	-	0.07	1E1
	S-50/80VPN10	1	-	-	0.42	1E1
	S40/80V	2	-	-	0.406	1E1
	S40/80VPN10	1	-	-	0.203	1E1
	S40/90rPN10	1	-	-	0.42	1E1
	S80/100V	1	-	-	0.6	1E1
	Z25	3	-	-	0.16	1E1
	Z2575	1	-	-	0.047	4C
	ZX100LD4	-	1	-	3	1E1
	D126	1	-	-	0.48	1E1,1E2
	D50003496/774	1	-	-	0.02	1E1,1E2
	D80	3	-	-	0.43	1E1,1E2,1K
	DPN50/224-1.5/4	-	2	-	3	1E2
	P40-2	1	-	-	0.075	1K
	P40/100V	1	-	-	0.075	1K
	RS25-2	2	-	-	0.02	1K
	DP100/200-3/4	-	1	-	3	1E1
	DPN65/250-4/4	-	1	-	4	5B
ZIEHL-ABEGG	DASS351/4/4	1	-	-	0.13	1M

Table 40

Manufacturers Responding to Survey

AEG Corporation
Bodine Electric Company
Carl Bockwoldt
Century Electric
Delco Products
Electra-Maschinen
Ervin Halder KG
Grundfos
Klein, Schanzlin GB
Loher AG
Maico
Reliance Electric
Robatherm Warme
Schluter Elektrom
Stephan Werke
Ziehl-Abegg
Baldor
Buderus
Centra-Burkle
Copeland Corporation
Dietz Motoren
EMU Unterwasserpump
General Electric Co.
Hawkar Siddley
Landis & Gyr Inc.
Louis Allis
Marathon Electric
Ritz Pumpenfabrik
Robert Birkenbeul
Siemens AG
Wilo Werke

In addition to collecting information from vendors whose equipment was found, USACERL surveyed all U.S. vendors who supply variable-speed controls for a.c. motor applications. Table 41 lists these vendors. This table includes vendor names, models offered by each vendor, adjustable-speed controller type, number of units sold, and application motor types. All controllers shown are for either induction or synchronous a.c. motors. As can be seen, as of mid-1987, more than 200,000 adjustable-speed controllers have been installed in the United States. Note that Toshiba and Hitachi have dominated the market and that PWM-type controllers have accounted for more than half of the units sold.

Economic Analysis of Electric Motor Replacement

Before field-testing the motors at Grafenwöhr and Hohenfels, USACERL needed to develop a strategy for analyzing the economics of motor replacement. The decision to replace an existing electric motor with a new high-efficiency motor must be based on economics. For motors to be replaced, there are also the options of purchasing a new high-efficiency motor vs. a less expensive new standard motor, as well as rebuilding an existing motor. These options should be compared by performing a life-cycle cost analysis that considers all relevant cash flows associated with operation of the electric motors. Due to the high variability in installation and maintenance costs, these issues are not addressed directly in this analytical strategy. However, for comparison of two new motors or rebuilding an existing motor, installation and maintenance costs should be nearly the same and can therefore be ignored. The analysis considers all other relevant variables such as purchase price, horsepower, load, efficiency, energy cost and escalation rate, running time per year, and discount rate.

The analysis of electric motor economics begins with computation of the effective interest rate. This rate is determined as a relationship between the expected annual rate of increase in power costs and the discount rate used in the analysis. Specifically, the equation is:

$$\text{Eff. Interest Rate} = \frac{(1 + \text{annual power cost increase})}{(1 + \text{discount rate})} - 1 \qquad \text{[Eq 2]}$$

This simple equation produces an effective interest rate that increases when the discount rate rises or the annual rate of increase in power costs falls. The effective interest rate determines the degree to which earlier and later cash flows are weighted in importance. Clearly, a faster escalation in power costs will cause later cash flows to be larger and assume more importance in the analysis. Conversely, a larger discount rate will cause earlier cash flows to be weighted more heavily. This analysis uses a discount rate of 12 percent and an expected annual rate of increase in power costs of 5 percent, which produces an effective interest rate of 6.67 percent:

$$\frac{(1 + 0.12)}{(1 + 0.05)} - 1 = 6.67\%$$

The next step is to determine the apparent years of operation considering present worth. This term adjusts the period for evaluation by a present worth factor which is determined by the effective rate of interest computed previously. The apparent years of operation, considering present worth, can be computed as follows:

$$\text{App. Years of Operation} = \frac{(1 + i)n - 1}{i(1 + i)^n} \qquad \text{[Eq 3]}$$

Table 41

Adjustable Speed Drive Manufacturer Survey

Manufacturer	Model	Hp	ASD Type†	First Installation	Units Installed	Motor Type††
Allen Bradley Drives Division P.O. Box 5 Cedarburg, WI 53012 414 377-1200	1330 1334 1340 1350	1-15 5-50 10-40 50-1,400	PWM PWM PWM PWM	1980 1982 1976 1982	* * * *	I&S I I&S I
ASEA Industrial Systems, Inc. P.O. Box 372 Milwaukee, WI 53201 414 785 3358	CONTRAC	0.5-750	PWM	1979	1,500	I
Autocon Industries, Inc. 925 University Avenue St. Paul, MN 55104 800 328 3351	VFD PT	0.75-350	PWM VSI	1985	150	I
Eaton Corp. Electric Drives Division 3122 14th Avenue Kenosha, WI 53141 414 656 4011	AF 5000 AF 7000	5-100 25-500	PWM VSI	1985 1982	335 1,200	I I
Emerson Electric Co. 3300 S. Standard Street Santa Ana, CA 92702 714 545 5581	AS200/AS5200 AS5100	1-50 50-1,400	VSI VSI	1981 1983	13,200 1,331	I&S I&S
General Electric Co. Speed Var. Products Oper. 1100 Lawrence Parkway Erie, PA 16531 814 875 2663	AF 200E AF-250E AFTROL II	0.5-10 7.5-50 1-15	PWM PWM VSI	1985 1986 1981	40 New 1,000	I I I
Graham Co. 8800 W. Bradley Road Milwaukee, WI 53223 414 355 8800	1520 Series 1576 Series	0.5-10 7.5-100	PWM VSI	1982 1981	200 800	I I
Hampton Products Co., Inc. Division of Danfoss 2995 Eastrock Drive Rockford, IL 61109 815 398 2770	VLT	1-30	VSI	1976	4,000	I
Hitachi America Ltd. 50 Prospect Avenue Tarrytown, NY 10591 914 332 5800 ×414	VIAF VWS Hitachi	15-200 1-200	PWM VSI	1985 1984	14 30,000	I I&S
Louis Allis Drives & Systems Div. 16555 Ryerson Road New Berlin, WI 53151 414 782 0200	Lancer 44XL Lancer 44XLP Lancer I Lancer Jr	5-1,500 15-2000 40-600 0.75-100	CSI CSI CSI PWM	1971 1973 1984 1983	1,002 1,000 181 3,015	I I I I&S
Lovejoy Electronics, Inc. 2655 Wisconsin Avenue Downers Grove, IL 60515 800 323 3534	MFR IV MFR V VSD S	1-10 15-25 3-75	PWM PWM PWM	1979 1984 1984	1,000 100 1,000	I&S I&S I&S
Marathon Electronics Avtek Drive Division 398 Beach Road Burlingame, CA 94010 415 347 3081	Pacesetter	1-75	PWM	1982	450	I
Mitsubishi Electric Sales America 799 Bierman Circle Mount Prospect, IL 60056 800 323 4216	Freqrol	0.5-75	PWM	1984	2,375	I
Parametrics Unit of ASEA 88 Marsh Hill Road Orange, CT 06477 203 795 0811	Parajust GX Parajust Y	0.5-10 5-60	PWM PWM	1985 1982	300 4,000	I&S I&S

Table 41 (Cont'd)

	Model	Hp	ASD Type†	First Installation	Units Installed	Motor Type††
Polyspede Electronics Co. 6770 Twin Hills Avenue Dallas, TX 75231 214 363 7245	Polydyne XLT	7.5-500 1-150	VSI PWM	1980 1982	60 700	I&S I&S
Relcon, Inc. 80 Walker Drive Brampton, Ontario LGT4H6 416 458 1100	AFR 7000 PWM9000	7.5-700 3-50	VSI PWM	1983 1984	413 386	I&S I&S
Reliance Electric Co. Electrical Drives Group 24703 Euclid Avenue Cleveland, OH 44117 216 266 7000	2VT GP 24C GP 24C VTAC I/1VT VTAC I/1VT	5-50 7.5-10 5-125 5-150 7.5-10	VSI VSI VSI VSI VSI	1984 1980 1980 1980 1980	1,200 1,000 3,000 4,000 1,500	I&S I&S I&S I&S I&S
Robicon Corp. 100 Sagamore Hill Road Pittsburgh, PA 15239 412 327 7000	Mark Series Opti Speed	15-5,000 5-40	CSI VSI	1979 1983	3,005 600	I I
Rondo Motor Control Division of Brown Boveri Ventron 2150 West 6th Avenue Broomfield, CO 80020 303 469 1742	TWK S	1-75	PWM	1978	10,000	I
Southcon 3608 Rozzells Ferry Road Charlotte, NC 28216 704 393 1636	Magnum	0.25-300	VSI	1981	6,750	I&S
Square D Co. P.O. Box 9247 Columbia, SC 29290 803 776 7500	CSI 1000 Omegapak Omegapak Type PF Ramsey HD Ramsey PF Ramsey XL	30-60 1-125 1-10 1-300 25-500 1-75	CSI PWM PWM PWM VSI VSI VSI	1983 1984 1986 1966 1982 1983	* 1,500 New * * *	I I I I&S I&S I&S
T.B. Woods' Sons Company 440 N. Fifth Avenue Chambersburg, PA 17201 717 264 7161	E-Trac Ultrac	0.5-50 25-250	PWM VSI	1985 1986	1,000 New	I&S I&S
Toshiba Inter. Corp. 13131 W. Little York Road Houston, TX 77041 713 466 0277	ESP130	1-300	PWM	1978	100,000	I
Vee-Arc Corp. 50 Milk Street Westborough, MA 01581 617 366 7451	PWM 7000 & Super 7000	3-125	PWM	1981	6,000	I&S
Voith Transmissions, Inc. 7 Pearl Court Allendale, NJ 07401 201 825 8855	Voturon	20-600	PWM	1982	89	I
Westinghouse Elec. Corp. Control Division P.O. Box 819 Oldsmar, FL 33557 813 855 4621	Accutrol 150 Accutrol 200 Accutrol 300	3-50 7.5-60 7.5-500	PWM PWM VSI	1983 1984 1982	* * *	I I I
York International Corp. P.O. Box 1592 York, PA 17405 717 771 6352	Air Modulator	5-50	VSI	1977	3,000	I

† CSI, current source inverter; CYC, cycloconverter; LCI, load commutated inverter; PWM, pulse width-modulated inverter; VSI, voltage-source inverter; WRSR, wound rotor slip recovery

†† I, induction; S, synchronous. Synchronous motors are normally not applied in this horsepower range, therefore, ASD cost curves for induction motors only are included

* Information not available at time of publication

A higher interest rate causes early cash flows to be weighted more heavily, and the apparent years of operation will decrease. Conversely, a smaller interest rate (caused by higher power costs or a lower discount rate) will give more weight to cash flows that occur later in time. This analysis uses a 7-year period of evaluation that is adjusted to 5.45 years through the apparent years of operation calculation:

$$\frac{(1 + 0.0667)^7 - 1}{0.0667(1 + 0.0667)^7} = 5.45 \text{ years}$$

The third step in the analysis is to compute the present worth evaluation factor (PWEF). This term is given in units of dollars per kilowatt and reflects the true savings to be realized over the project life for each kilowatt of electricity saved. The PWEF is calculated as the product of three terms:

PWEF = Cost of Energy ($/kWh) x Running Time (hr/year). Apparent Years of Operation [Eq 4]

PWEF for this analysis assumes a cost of energy of $0.04/kWh and a running time of 8760 hr/year:

$$0.04 \times 8760 \times 5.45 = \$1911/\text{kW}$$

The final step in the analysis is to compute the present worth of inefficiency-related losses associated with operation of the electric motor. This calculation does not deal with the electric power actually used to operate the motor, but rather the amount of power wasted in operation due to inefficiencies within the motor:

Pres. Worth of Motor Losses =

$$0.746 \times HP \times PWEF \times (100/Efficiency - 1) \qquad \text{[Eq 5]}$$

This final calculation estimates the dollar savings that can be realized through operation of a high-efficiency electric motor. For example, the present worth of losses from a standard motor can be subtracted from the present worth of losses from a high-efficiency motor to determine the savings from operating of the higher efficiency unit. The difference in the total cost of the motors, however, must take into account the initial purchase price of the motor. Because the high-efficiency motors generally cost more than standard motors, they must recoup their greater initial cost through operating savings. In the replacement decision, the cost and operating savings the high-efficiency motor must be compared with the standard efficiency motor, which has a cost of zero because it is already in operation. Thus, the higher efficiency motor must achieve a present worth of operating savings great enough to offset the initial purchase cost of a new motor.

Example Cases

The economic analysis methodology described above has been applied to a variety of situations involving purchase/replacement of electric motors. Example case studies are presented here to illustrate use of the method. The first set of cases analyzed covers new high-efficiency motors of 5, 50, 100, and 200 HP compared with new standard efficiency motors of the same horsepowers. This situation would occur when an electric motor must be replaced and the two options are to purchase a more expensive high-efficiency motor or a lower cost standard efficiency motor. As can be seen from the results in Tables 42 through 45, the higher efficiency motors are clearly the more economical choice, producing total cost savings of between $500 and $4500, depending on the motor size. Larger motors bring greater total cost savings because the improvement in efficiency is spread over a larger amount of energy consumed.

Table 42

New 5-HP High-Efficiency Motor vs. New 5-HP Standard Efficiency Motor

I N P U T   D A T A

5.00%	=	EXPECTED ANNUAL RATE OF INCREASE IN POWER COST, %
12.00%	=	DISCOUNT RATE, %
0.04	=	AVERAGE ENERGY COST, $/kWh
8760	=	RUNNING TIME, hours per year
7	=	NUMBER OF YEARS OF OPERATION (period for evaluation)
5	=	HORSEPOWER OF MOTOR A
		100%= LOAD
5	=	HORSEPOWER OF MOTOR B
		100%= LOAD
88.50%	=	EFFICIENCY OF MOTOR A, %
82.50%	=	EFFICIENCY OF MOTOR B, %
431	=	INITIAL COST OF MOTOR A, $
329	=	INITIAL COST OF MOTOR B, $

O U T P U T   D A T A

EFFECTIVE INTEREST RATE, %	=	6.67%
APPARENT YEARS OF OPERATION	=	5.45
PRES.WORTH EVALUATION FACTOR,$/kW	=	1911

M O T O R   A

PRESENT WORTH OF MOTOR LOSSES, $	=	926.02
INITIAL COST OF MOTOR, $	=	431.00
TOTAL COST OF MOTOR A, $	=	1357.02

M O T O R   B

PRESENT WORTH OF MOTOR LOSSES, $	=	1511.65
INITIAL COST OF MOTOR, $	=	329.00
TOTAL COST OF MOTOR B, $	=	1840.65

Table 43

New 50-HP High-Efficiency Motor vs. New 50-HP
Standard Efficiency Motor

```
       I N P U T   D A T A
       -------------------

  5.00%= EXPECTED ANNUAL RATE OF INCREASE IN POWER COST, %
 12.00%= DISCOUNT RATE, %
  0.04 = AVERAGE ENERGY COST, $/kWh
  8760 = RUNNING TIME, hours per year
     7 = NUMBER OF YEARS OF OPERATION (period for evaluation)
    50 = HORSEPOWER OF MOTOR A
            100%= LOAD
    50 = HORSEPOWER OF MOTOR B
            100%= LOAD
 93.00%= EFFICIENCY OF MOTOR A, %
 89.50%= EFFICIENCY OF MOTOR B, %
  2199 = INITIAL COST OF MOTOR A, $
  1874 = INITIAL COST OF MOTOR B, $


       O U T P U T   D A T A
       ---------------------
EFFECTIVE INTEREST RATE, %          =     6.67%
APPARENT YEARS OF OPERATION         =     5.45
PRES.WORTH EVALUATION FACTOR,$/kW   =     1911

                 M O T O R   A
                 -------------
       PRESENT WORTH OF MOTOR LOSSES, $  =   5363.93
       INITIAL COST OF MOTOR, $          =   2199.00
                                             -------
       TOTAL COST OF MOTOR A, $          =   7562.93

                 M O T O R   B
                 -------------
       PRESENT WORTH OF MOTOR LOSSES, $  =   8360.53
       INITIAL COST OF MOTOR, $          =   1874.00
                                            --------
       TOTAL COST OF MOTOR B, $          =  10234.53
```

Table 44

New 100-HP High-Efficiency Motor vs. New 100-HP Standard Efficiency Motor

```
        I N P U T   D A T A
        -- ----- ----------

   5.00%= EXPECTED ANNUAL RATE OF INCREASE IN POWER COST, %
  12.00%= DISCOUNT RATE, %
   0.04 = AVERAGE ENERGY COST, $/kWh
   8760 = RUNNING TIME, hours per year
      7 = NUMBER OF YEARS OF OPERATION (period for evaluation)
    100 = HORSEPOWER OF MOTOR A
               100%= LOAD
    100 = HORSEPOWER OF MOTOR B
               100%= LOAD
  94.50%= EFFICIENCY OF MOTOR A, %
  91.70%= EFFICIENCY OF MOTOR B, %
   4378 = INITIAL COST OF MOTOR A, $
   4002 = INITIAL COST OF MOTOR B, $


        O U T P U T   D A T A
        -----------  ----------

EFFECTIVE INTEREST RATE, %            =      6.67%
APPARENT YEARS OF OPERATION           =      5.45
PRES.WORTH EVALUATION FACTOR,$/kW     =      1911

                M O T O R   A
                - - - - - - -

        PRESENT WORTH OF MOTOR LOSSES, $    =   8295.23
        INITIAL COST OF MOTOR, $            =   4378.00
                                                -------
        TOTAL COST OF MOTOR A, $            =  12673.23

                M O T O R   B
                - - - - - - -

        PRESENT WORTH OF MOTOR LOSSES, $    =  12900.50
        INITIAL COST OF MOTOR, $            =   4002.00
                                               --------
        TOTAL COST OF MOTOR B, $            =  16902.50
```

Table 45

New 200-HP High-Efficiency Motor vs. New 200-HP Standard Efficiency Motor

```
        I N P U T   D A T A
        --------------------

    5.00%= EXPECTED ANNUAL RATE OF INCREASE IN POWER COST, %
   12.00%= DISCOUNT RATE, %
    0.04 = AVERAGE ENERGY COST, $/kWh
    8760 = RUNNING TIME, hours per year
       7 = NUMBER OF YEARS OF OPERATION (period for evaluation)
     200 = HORSEPOWER OF MOTOR A
              100%= LOAD
     200 = HORSEPOWER OF MOTOR B
              100%= LOAD
   95.00%= EFFICIENCY OF MOTOR A, %
   93.00%= EFFICIENCY OF MOTOR B, %
   10307 = INITIAL COST OF MOTOR A, $
    8372 = INITIAL COST OF MOTOR B, $


        O U T P U T   D A T A
        ----------------------
EFFECTIVE INTEREST RATE, %           =      6.67%
APPARENT YEARS OF OPERATION          =      5.45
PRES.WORTH EVALUATION FACTOR,$/kW    =      1911

                 M O T O R   A
                 -------------
        PRESENT WORTH OF MOTOR LOSSES, $   = 15002.86
        INITIAL COST OF MOTOR, $           = 10307.00
                                             --------
        TOTAL COST OF MOTOR A, $           = 25309.86

                 M O T O R   B
                 -------------
        PRESENT WORTH OF MOTOR LOSSES, $   = 21455.70
        INITIAL COST OF MOTOR, $           =  8372.00
                                             ---------
        TOTAL COST OF MOTOR B, $           = 29827.70
```

The second set of cases focuses on the optional replacement of a functional, existing standard efficiency electric motor with a high-efficiency motor. The two options are to purchase the high-efficiency unit and use it as a replacement for the existing unit, or to do nothing and continue to operate the existing unit. This case requires that the lower operating cost of the high-efficiency motor be great enough to offset its purchase price. Consideration is not given to the purchase price of the existing unit, because it is already in operation and presumably does not require replacement for any reason other than cost savings. The results in Tables 46 through 49 show that replacement of an average standard efficiency electric motor is economical up to the 100-HP size based on the assumptions used in this analysis. Beyond that point, the purchase price of the high-efficiency unit cannot be recovered through operating cost savings. Therefore, replacement of an existing motor of greater than 100 HP cannot be recommended on economics alone. Some consideration could be given to the age and condition of the existing unit, because replacement of a recently acquired standard efficiency unit is not directly comparable to replacement of an aged unit.

The third case analyzed deals with the issue of oversized motors vs. correctly sized motors. In some situations, it may be economical to purchase a motor with greater capacity than is required and operate it at reduced load levels. For this case, the high-efficiency motors of a given size were evaluated at 50 percent load and compared with high-efficiency motors of half size evaluated at 100 percent load. The results in Table 50 show that it is more economical to purchase and operate a 10-HP motor at 50 percent load than a 5-HP motor at 100 percent load. This result is due to the 4 percent higher half-load efficiency of the 10-HP motor compared with the full-load efficiency of the 5-HP motor, while the 10-HP motor costs only $234 more. This situation was analyzed for larger motors as well, where a 50-HP motor running at 100 percent load was compared with a 100-HP motor running at 50 percent. The results in Table 51 show that, in this instance, the oversized motor was not more economical to purchase and operate because there was only a 1.2 percent increase in the half-load efficiency of the larger motor compared with the full-load efficiency of the smaller motor, while there was a $2200 premium to purchase the oversized motor. Thus, the use of oversized electric motors appears to be economical at lower horsepower levels. This analysis assumes that the oversized motor is no more than twice the required size. Most induction motors suffer severe efficiency penalties when operated below 50 percent capacity.

The fourth case used the series of curves in Figures 67 through 70 which depict high-efficiency motors vs. standard efficiency motors under a variety of load conditions. The total cost to produce and operate the 5-, 50-, 100-, and 200-HP motors under load conditions of 50 percent, 75 percent, and full load was determined and computed for high-efficiency and standard efficiency motors. For all load levels, the total cost to purchase and operate the high-efficiency motors was lower. The curves show, however, that the advantage of the high-efficiency motors is greatest near full load. The economic advantage of the high-efficiency units decreases as load conditions fall toward the 50 percent load level.

Motor efficiency is summarized in Table 52 in terms of dollars per horsepower as well as the present worth of motor losses for the 5-, 50-, 100-, and 200-HP motors examined. This table can be used to determine the present worth of motor losses for both standard efficiency and high-efficiency electric motors by choosing the efficiency to be examined in the left column and reading across to the $/HP column. This term indicates present worth of motor losses for the given efficiency in a 1-HP motor. To determine the present worth of motor losses for a given horsepower, the columns on the right are simply the dollars per horsepower multiplied by the actual horsepower of the motor (5, 50, 100, or 200). This motor efficiency evaluation table makes it easy to compute the total cost of operating an electric motor. For example, the 50-HP base-case motor examined earlier had an associated efficiency of 93 percent. To compute the present worth of motor losses from the table, simply choose 93 percent in the efficiency column of the table and read across to the column marked "Present Worth of Motor Loss" for 50-HP motors, which gives $5364. This number corresponds to the $5363.93 calculated in the original analysis (difference due to truncation of cents in the table). To determine the total cost of owning and operating the motor, add the initial cost of the motor, in this case $4378, to the present worth of motor loss for a

Table 46

Replacement of Existing 5-HP Standard Efficiency Motor With a 5-HP High-Efficiency Motor

```
INPUT  DATA
--------------------

 5.00%= EXPECTED ANNUAL RATE OF INCREASE IN POWER COST, %
12.00%= DISCOUNT RATE, %
  0.04 = AVERAGE ENERGY COST, $/kWh
  8760 = RUNNING TIME, hours per year
     7 = NUMBER OF YEARS OF OPERATION (period for evaluation)
     5 = HORSEPOWER OF MOTOR A
            100%= LOAD
     5 = HORSEPOWER OF MOTOR B
            100%= LOAD
88.50%= EFFICIENCY OF MOTOR A, %
82.50%= EFFICIENCY OF MOTOR B, %
   431 = INITIAL COST OF MOTOR A, $
     0 = INITIAL COST OF MOTOR B, $


OUTPUT  DATA
----------------------

EFFECTIVE INTEREST RATE, %           =     6.67%
APPARENT YEARS OF OPERATION          =     5.45
PRES.WORTH EVALUATION FACTOR,$/kW    =     1911

            M O T O R   A
            -------------

PRESENT WORTH OF MOTOR LOSSES, $   =    926.02
INITIAL COST OF MOTOR, $           =    431.00
                                       -------
TOTAL COST OF MOTOR A, $           =   1357.02

            M O T O R   B
            -------------

PRESENT WORTH OF MOTOR LOSSES, $   =   1511.65
INITIAL COST OF MOTOR, $           =      0.00
                                       -------
TOTAL COST OF MOTOR B, $           =   1511.65
```

Table 47

Replacement of Existing 50-HP Standard Efficiency Motor With a 50-HP High-Efficiency Motor

```
        I N P U T   D A T A
        -------------------

    5.00%= EXPECTED ANNUAL RATE OF INCREASE IN POWER COST, %
   12.00%= DISCOUNT RATE, %
    0.04 = AVERAGE ENERGY COST, $/kWh
    8760 = RUNNING TIME, hours per year
       7 = NUMBER OF YEARS OF OPERATION (period for evaluation)
      50 = HORSEPOWER OF MOTOR A
             100%= LOAD
      50 = HORSEPOWER OF MOTOR B
             100%= LOAD
   93.00%= EFFICIENCY OF MOTOR A, %
   89.50%= EFFICIENCY OF MOTOR B, %
    2199 = INITIAL COST OF MOTOR A, $
       0 = INITIAL COST OF MOTOR B, $


        O U T P U T   D A T A
        ---------------------
EFFECTIVE INTEREST RATE, %          =      6.67%
APPARENT YEARS OF OPERATION         =      5.45
PRES.WORTH EVALUATION FACTOR,$/kW   =      1911

                 M O T O R   A
                 -------------
        PRESENT WORTH OF MOTOR LOSSES, $  =  5363.93
        INITIAL COST OF MOTOR, $          =  2199.00
                                             --------
        TOTAL COST OF MOTOR A, $          =  7562.93

                 M O T O R   B
                 -------------
        PRESENT WORTH OF MOTOR LOSSES, $  =  8360.53
        INITIAL COST OF MOTOR, $          =     0.00
                                             --------
        TOTAL COST OF MOTOR B, $          =  8360.53
```

Table 48

Replacement of Existing 100-HP Standard Efficiency Motor With a 100-HP High-Efficiency Motor

INPUT DATA

5.00%	=	EXPECTED ANNUAL RATE OF INCREASE IN POWER COST, %
12.00%	=	DISCOUNT RATE, %
0.04	=	AVERAGE ENERGY COST, $/kWh
8760	=	RUNNING TIME, hours per year
7	=	NUMBER OF YEARS OF OPERATION (period for evaluation)
100	=	HORSEPOWER OF MOTOR A
		100%= LOAD
100	=	HORSEPOWER OF MOTOR B
		100%= LOAD
94.50%	=	EFFICIENCY OF MOTOR A, %
91.70%	=	EFFICIENCY OF MOTOR B, %
4378	=	INITIAL COST OF MOTOR A, $
0	=	INITIAL COST OF MOTOR B, $

OUTPUT DATA

EFFECTIVE INTEREST RATE, %	=	6.67%
APPARENT YEARS OF OPERATION	=	5.45
PRES.WORTH EVALUATION FACTOR,$/kW	=	1911

MOTOR A

PRESENT WORTH OF MOTOR LOSSES, $	=	8295.23
INITIAL COST OF MOTOR, $	=	4378.00
TOTAL COST OF MOTOR A, $	=	12673.23

MOTOR B

PRESENT WORTH OF MOTOR LOSSES, $	=	12900.50
INITIAL COST OF MOTOR, $	=	0.00
TOTAL COST OF MOTOR B, $	=	12900.50

Table 49

Replacement of Existing 200-HP Standard Efficiency Motor
With a 200-HP High-Efficiency Motor

```
          I N P U T   D A T A
          -------------------

     5.00%= EXPECTED ANNUAL RATE OF INCREASE IN POWER COST, %
    12.00%= DISCOUNT RATE, %
     0.04 = AVERAGE ENERGY COST, $/kWh
     8760 = RUNNING TIME, hours per year
        7 = NUMBER OF YEARS OF OPERATION (period for evaluation)
      200 = HORSEPOWER OF MOTOR A
                100%= LOAD
      200 = HORSEPOWER OF MOTOR B
                100%= LOAD
    95.00%= EFFICIENCY OF MOTOR A, %
    93.00%= EFFICIENCY OF MOTOR B, %
    10307 = INITIAL COST OF MOTOR A, $
        0 = INITIAL COST OF MOTOR B, $


          O U T P U T   D A T A
          ---------------------
EFFECTIVE INTEREST RATE, %           =      6.67%
APPARENT YEARS OF OPERATION          =      5.45
PRES.WORTH EVALUATION FACTOR,$/kW =         1911

                   M O T O R   A
                   -------------

          PRESENT WORTH OF MOTOR LOSSES, $   = 15002.86
          INITIAL COST OF MOTOR, $           = 10307.00
                                               --------
          TOTAL COST OF MOTOR A, $           = 25309.86

                   M O T O R   B
                   -------------

          PRESENT WORTH OF MOTOR LOSSES, $   = 21455.70
          INITIAL COST OF MOTOR, $           =     0.00
                                               ---------
          TOTAL COST OF MOTOR B, $           = 21455.70
```

Table 50

Oversize Analysis of a 10-HP High-Efficiency Motor at 50 Percent Load vs. a 5-HP Standard Efficiency Motor at 100 Percent Load

```
        I N P U T   D A T A
        -------------------

    5.00%= EXPECTED ANNUAL RATE OF INCREASE IN POWER COST, %
   12.00%= DISCOUNT RATE, %
    0.04 = AVERAGE ENERGY COST, $/kWh
    8760 = RUNNING TIME, hours per year
       7 = NUMBER OF YEARS OF OPERATION (period for evaluation)
      10 = HORSEPOWER OF MOTOR A
               50%= LOAD
       5 = HORSEPOWER OF MOTOR B
              100%= LOAD
   92.30%= EFFICIENCY OF MOTOR A, %
   88.50%= EFFICIENCY OF MOTOR B, %
     665 = INITIAL COST OF MOTOR A, $
     431 = INITIAL COST OF MOTOR B, $


        O U T P U T   D A T A
        ---------------------
EFFECTIVE INTEREST RATE, %          =     6.67%
APPARENT YEARS OF OPERATION         =     5.45
PRES.WORTH EVALUATION FACTOR,$/kW =     1911

                 M O T O R   A
                 -------------
        PRESENT WORTH OF MOTOR LOSSES, $   =    594.51
        INITIAL COST OF MOTOR, $           =    665.00
                                               --------
        TOTAL COST OF MOTOR A, $           =   1259.51

                 M O T O R   B
                 -------------
        PRESENT WORTH OF MOTOR LOSSES, $   =    926.02
        INITIAL COST OF MOTOR, $           =    431.00
                                               ---------
        TOTAL COST OF MOTOR B, $           =   1357.02
```

Table 51

Oversize Analysis of a 100-HP High-Efficiency Motor at 50 Percent Load vs. a 50-HP Standard Efficiency Motor at 100 Percent Load

```
         I N P U T   D A T A
         -------------------

    5.00%= EXPECTED ANNUAL RATE OF INCREASE IN POWER COST, %
   12.00%= DISCOUNT RATE, %
    0.04 = AVERAGE ENERGY COST, $/kWh
    8760 = RUNNING TIME, hours per year
       7 = NUMBER OF YEARS OF OPERATION (period for evaluation)
     100 = HORSEPOWER OF MOTOR A
               50%= LOAD
      50 = HORSEPOWER OF MOTOR B
              100%= LOAD
   94.20%= EFFICIENCY OF MOTOR A, %
   93.00%= EFFICIENCY OF MOTOR B, %
    4378 = INITIAL COST OF MOTOR A, $
    2199 = INITIAL COST OF MOTOR B, $


         O U T P U T   D A T A
         ----------------------
EFFECTIVE INTEREST RATE, %          =     6.67%
APPARENT YEARS OF OPERATION         =     5.45
PRES.WORTH EVALUATION FACTOR,$/kW   =     1911

                  M O T O R   A
                  -------------
         PRESENT WORTH OF MOTOR LOSSES, $  =  4387.78
         INITIAL COST OF MOTOR, $          =  4378.00
                                             --------
         TOTAL COST OF MOTOR A, $          =  8765.78

                  M O T O R   B
                  -------------
         PRESENT WORTH OF MOTOR LOSSES, $  =  5363.93
         INITIAL COST OF MOTOR, $          =  2199.00
                                             ---------
         TOTAL COST OF MOTOR B, $          =  7562.93
```

Table 52

Motor Efficiency for 5-, 50-, 100-, and 200-HP Motors

Efficiency	$/HP	Present worth Motor Loss	Present Worth Motor Loss	Present Worth Motor Loss	Present Worth Motor Loss
0.6	950.18	4751	47509	95018	190036
0.61	911.24	4556	45562	91124	182248
0.62	873.55	4368	43678	87355	174711
0.63	837.06	4185	41853	83706	167413
0.64	801.72	4009	40086	80172	160343
0.65	767.45	3837	38373	76745	153491
0.66	734.23	3671	36712	73423	146846
0.67	702.00	3510	35100	70200	140400
0.68	670.72	3354	33536	67072	134143
0.69	640.34	3202	32017	64034	128068
0.7	610.83	3054	30542	61083	122166
0.71	582.15	2911	29108	58215	116431
0.72	554.27	2771	27714	55427	110854
0.73	527.16	2636	26358	52716	105431
0.74	500.77	2504	25039	50077	100154
0.75	475.09	2375	23755	47509	95018
0.76	450.09	2250	22504	45009	90017
0.77	425.73	2129	21287	42573	85146
0.78	402.00	2010	20100	40200	80400
0.79	378.87	1804	18943	37887	75774
0.8	356.32	1782	17816	35632	71264
0.81	334.32	1672	16716	33432	66865
0.82	312.86	1564	15643	31286	62573
0.83	291.92	1460	14596	29192	58385
0.84	271.48	1357	13574	27148	54296
0.85	251.52	1258	12576	25152	50304
0.86	232.02	1160	11601	23202	46404
0.87	212.97	1065	10649	21297	42594
0.88	194.36	972	9718	19436	38871
0.89	176.16	881	8808	17616	35231
0.9	158.36	792	7918	15836	31673
0.91	140.96	705	7048	14096	28192
0.92	123.94	620	6197	12394	24787
0.93	107.28	536	5364	10728	21456
0.94	90.97	455	4549	9097	18195
0.95	75.01	375	3751	7501	15003
0.96	59.39	297	2969	5939	11877
0.97	44.08	220	2204	4408	8816

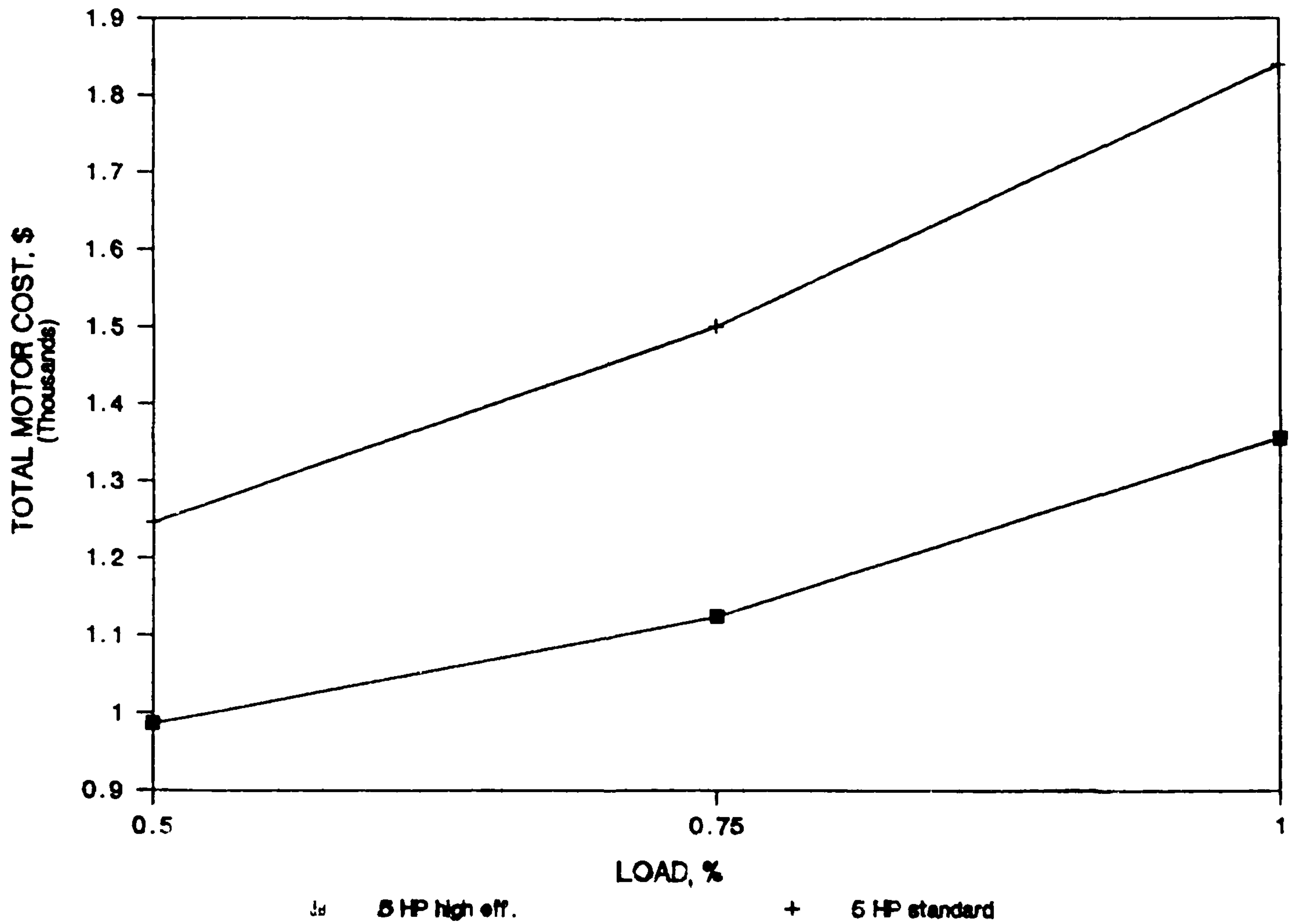


Figure 67. Total motor cost as a function of load for 5-HP electric motors.

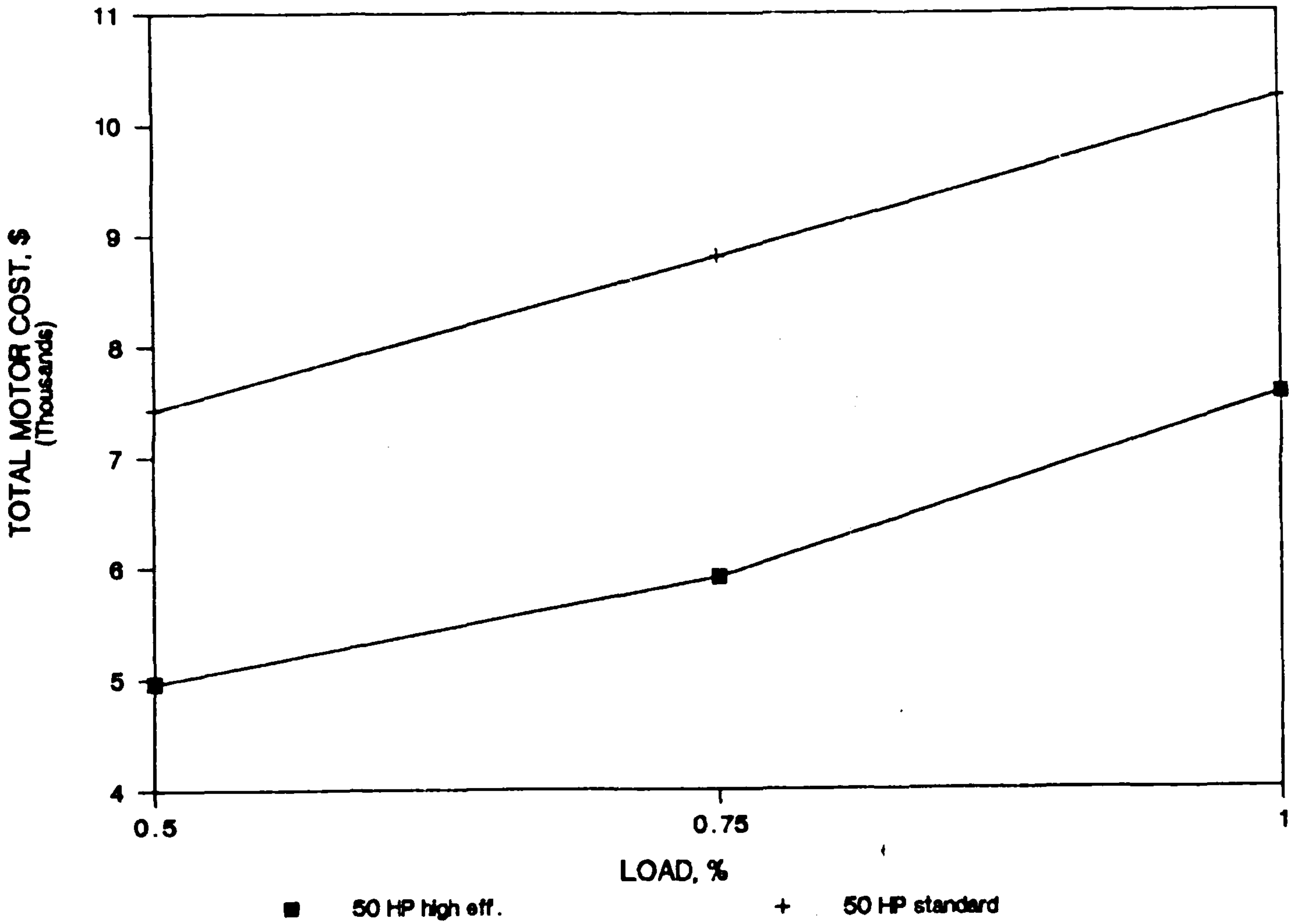


Figure 68. Total motor cost as a function of load for 50-HP electric motors.

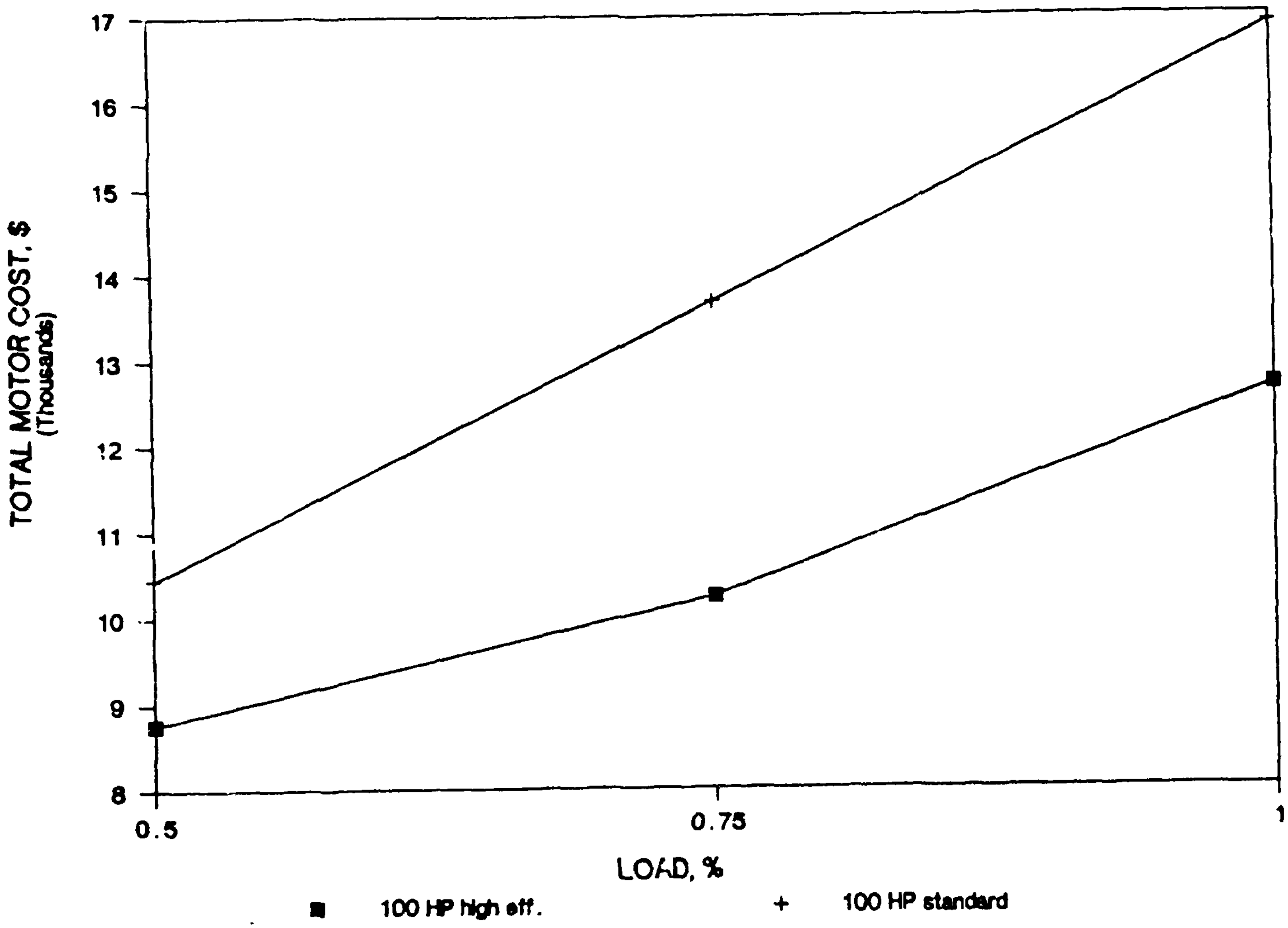


Figure 69. Total motor cost as a function of load for 100-HP electric motors.

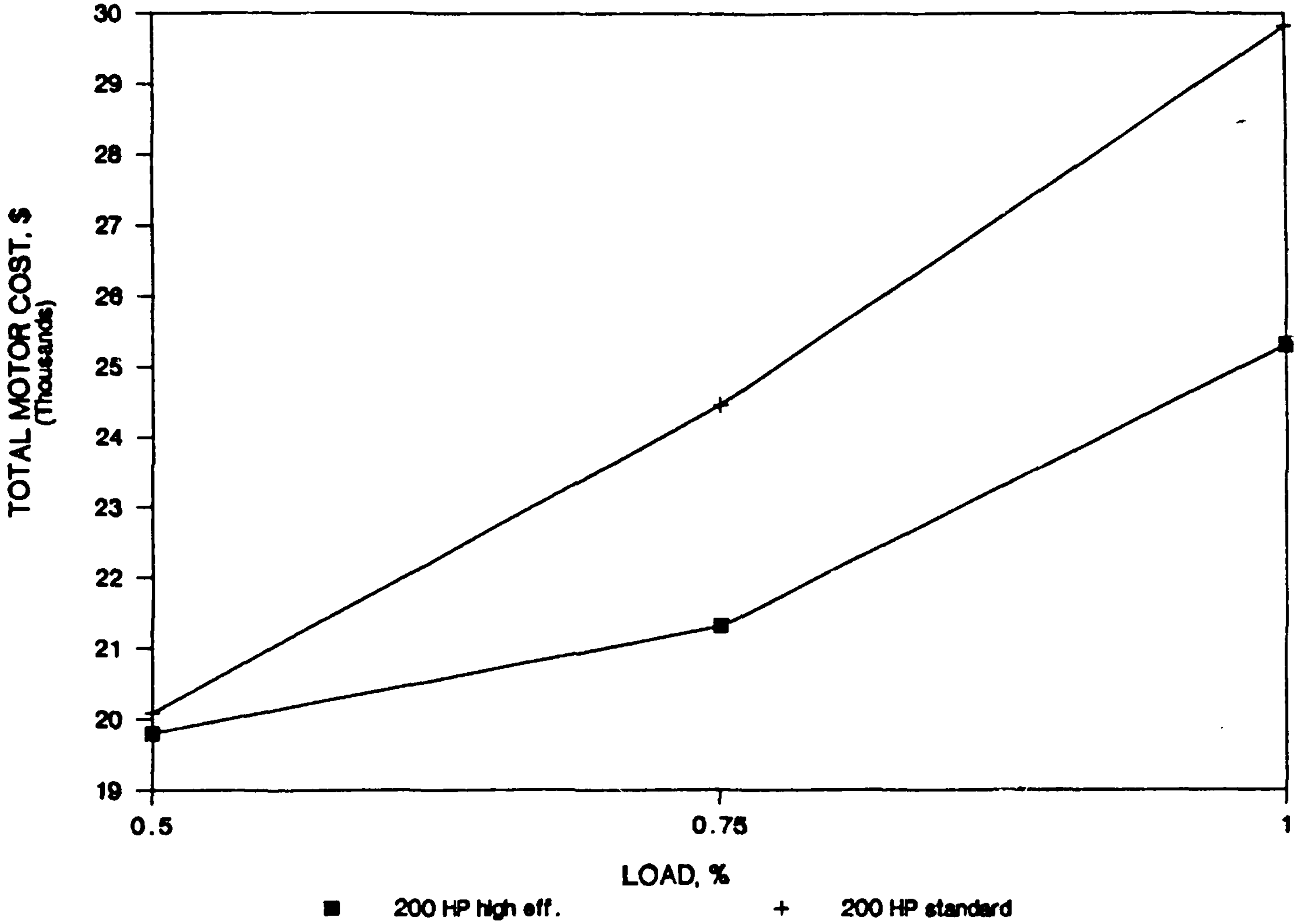


Figure 70. Total motor cost as a function of load for 200-HP electric motors.

total cost of $12,673. One fact which must be emphasized is that the dollars per horsepower figure given is based on a $0.04/kWh energy cost with 5 percent annual escalation, 8760 hr/year operation, 7-year evaluation period, and discount rate of 12 percent. Any deviation from these assumptions will invalidate the motor efficiency evaluation table.

The motor efficiency evaluation table can also be used to evaluate the economics of motor rewinding or rebuilding. The value of the rebuild can be determined by estimating the motor efficiencies before and after rebuilding and finding the present worth of motor losses associated with those efficiencies in the table. The cost of the rebuild must not exceed the present worth of the improvement in motor operating costs. For example, a rebuild of a 100-HP motor that increases the efficiency from 89 percent to 91 percent will lower the present worth of motor losses from $17,616 to $14,096. Thus, the cost of the rebuild must not exceed this difference of $3520.

Economic Analysis Spreadsheet Model

A Lotus 1-2-3 spreadsheet was prepared which contains the electric motor analysis method used to evaluate all cases discussed here. Also included in the spreadsheet is the motor efficiency evaluation table which is computed from the input data on the first screen. A change in any of the input data will automatically update the motor efficiency evaluation table and allow for easy calculation of the present worth of motor losses for any given set of circumstances.

The spreadsheet is designed such that input data are required only in the first screen, and includes items such as discount rate, cost of energy and escalation rate, running time per year, number of years of operation, horsepower and load (which should be consistent between motors A and B for a proper analysis), motor efficiencies, and initial motor cost (which should be zero for motor B during a replacement decision). The screen immediately below the input screen gives the output data for the model, which consists of present worth of motor losses added to the initial cost and gives the total cost of the motor. Also displayed in this screen are values for intermediate calculations such as effective interest rate, apparent years of operation, and present worth evaluation factor. The motor efficiency evaluation table is displayed immediately below the output data. Two macros have been created to expedite the printing of the spreadsheet.

Field Testing

The objective of USACERL's field testing was to perform measurements on electric motors based on the audit results. Before going to the field, USACERL developed a test plan and strategy to detect which categories of electric motors might be oversized for their present applications.

Motor Testing

An induction motor is essentially a transformer in which the stator winding is the primary and the rotor winding is the secondary. When a three-phase voltage is applied to the stator, the resulting stator current produces a rotating magnetic field which induces current in the short-circuited secondary. The interaction of the rotating magnetic field produced by the stator and the magnetic field produced by the induced current in the short-circuit rotor results in a torque which is high enough, when the motor is stationary, to accelerate the motor and its connected load to its designed running speed. The speed of the rotating magnetic field produced by the stator is a function of line frequency. It is either equal to the line frequency or a submultiple of line frequency divisible by the number of pole pairs in the stator. This speed is called the "synchronous speed." For 60-Hz line frequency, the synchronous speed of an induction motor would be 3600 RPM for a two-pole motor, 1800 RPM for a four-pole motor, and so on.

An induction motor cannot run at synchronous speed because to do so would spin the rotor at the same speed as the rotating flux and there would be no induction. The difference in speed between the synchronous and actual speed is called "slip."

When an induction motor is heavily loaded, the slip is greater than when the motor is unloaded. Consequently, the current in both the stator and the induced current in the rotor are higher than when the slip is less. Current in the stator and rotor reach maximum when the rotor is stopped. At this point, the energy losses in the motor are due to the current heating the conductors of the rotor and stator and are referred to as "I^2R losses" or "copper losses."

When an induction motor is unloaded and spinning freely, the slip is minimal--usually about 1 RPM. Consequently, current in the stator and rotor are minimal, and therefore, losses in the copper are negligible. The power consumed is lost mainly in magnetic hysteresis and eddy currents, with a very small percentage lost in friction and windage. These no-load losses are collectively called "iron losses."

It is possible to perform two tests on a motor to isolate the two forms of losses. The no-load test, as its name implies, operates the motor at rated voltage with no load applied mechanically to the shaft. At rated voltage, most of the current is used to produce the magnetic field and the power consumed is almost all iron losses with a small amount of friction and windage. Since a motor normally operates at its rated voltage, the iron losses will remain fairly constant throughout its load range.

Information about the magnetizing branch can be obtained from a no-load test performed by applying a balanced three-phase voltage to the motor, which is uncoupled from its load. At no load and rated voltage, the input power is used to supply three losses: stator copper, stator core, and rotational losses. From the no-load test, the core loss resistor and the magnetizing reactance can be determined. An equation for this determination is:

$$P_o = 3\, I_o^2\, R_1 + P_c + P_{rot} \qquad \text{[Eq 6]}$$

where:
- P_o = Input power at no load.
- R_1 = Effective stator resistance per phase.
- P_c = Stator core loss.
- P_{rot} = Rotational losses.

The other test is the blocked rotor test (sometimes referred to as the short-circuit test). In this test, the rotor is held in a stationary position while the motor's rated current is applied to the stator coils. Consequently, the input impedance of the equivalent circuit is quite low. Reduced balance three-phase voltage is applied to the motor to limit rotor current. Under these conditions, the stationary rotor eliminates all friction and windage losses and the reduced stator voltage needed to produce rated current reduces the iron losses to negligible amounts so that the power consumed by the motor is all copper losses. From the blocked rotor test measurements, the effective value of the impedance can be determined as follows:

$$R_e = R_1 + R'_2 = P_b / 3\, I_b^2 \qquad \text{[Eq 7]}$$

and

$$\begin{aligned} Xe &= \sqrt{(Z_e^2 - R_e^2)} \qquad \text{[Eq 8]} \\ &= \sqrt{(V_b^2 / 3I_b^2) - R_e^2)} \\ &= X_1 + X'_2 \end{aligned}$$

where: R_e = Equivalent winding resistance per phase.
R_1 = Stator winding resistance per phase.
Z_e = Equivalent phase impedance.
X_e = Equivalent leakage resistance.
R'_2 = Effective rotor winding resistance per phase referred to the stator.
X_1 = Stator leakage reactance per phase.
X'_2 = Rotor leakage reactance per phase referred to the stator.
P_b = Input power under blocked rotor conditions.
V_b = Three-phase voltage applied to stator.
I_b = Motor line current.

With the data obtained from the no-load and blocked rotor test of the induction motor--i.e., voltage, current, phase angles, and power (reactive and resistive)--a circle diagram can be constructed which graphically approximates the motor's characteristics throughout its operating range. From this circle diagram, the efficiency of any electric motor can be determined with great accuracy.

Unfortunately, it is not practical to perform tests like the no-load and blocked rotor test in the field. While input power can be measured readily and accurately, it is impossible to measure the power delivered to a typical applied motor load with enough accuracy to compute the efficiency of the motor. A paper entitled "Army Saves Energy by Identifying and Replacing Oversized Motors" describes a method of approximating motor load by comparing the measured revolutions per minute of a working motor to its nameplate revolutions per minute. A copy of this paper is presented in Appendix E. By calculating the ratio of the measured slip to the nameplate slip and multiplying this factor into the nameplate power, the power delivered to the load can be approximated. While the theory behind this method is correct in that the test yields a good approximation of motor load, it is based on the accuracy of motor nameplate data, which is not necessarily high enough to compute motor efficiency. For this reason, a hand-held powermeter was used to perform additional motor tests in order to verify manufacturers' nameplate specifications.

The instrument selected for the test was an Esterline Angus Model 8198E-M a.c. powermeter. This multitester will measure most a.c. parameters on both balanced and unbalanced power circuits and will make polyphase determinations. Microprocessors in the instrument automatically provide kilowatt, kVAR, kilovolt-ampere, and power factor determinations. A memory function allows phase angle sequence and voltage firing angle calculations. Additional features include kWhr, kVARhr, and average power factor, plus the program calculates inrush current and peak/valley values.

The above method of measuring percentage of full load on an induction motor was proposed for detecting oversized motors operating at less than rated load, the premise being that the efficiency of any motor peaks at or very near its rated load. While this premise is essentially correct for standard designs and the new energy-efficient designs of constant speed induction motors, it must be pointed out that the efficiency curve for these motors is relatively flat throughout the motors' practical operating range. The efficiency of an induction motor begins to decline dramatically at loads of about 50 percent or less of rated load and at loads exceeding about 115 percent of rated load. Another important point to note is that this technique has been tested only for NEMA Design B motors, which are relatively low-starting torque polyphase induction motors. It was unclear whether European designed motors would show the same changes in revolutions per minute with load. In addition, no tests were performed on other NEMA motor designs to determine if similar relationships hold. Motor performance data collected during the audit were not detailed enough to analyze the RPM/load relationship.

Test Approach

Several criteria must be considered in order to identify potentially oversized motor populations. These criteria include duty factors, application, motor design, and motor size. Other factors that must be considered are the number of motors within a building profile and within an application code. To identify potentially oversized motor applications, the motor data collected from Grafenwöhr and Hohenfels were sorted based on these factors. As noted during the field survey, several motors identified at each base were already of advanced design and engineered to handle multiple loads. As presented in Tables 27 and 28 for Grafenwöhr and Hohenfels, respectively, several applications, such as pumps used in HVAC systems, already have energy-saving multispeed motors. Furthermore, it was recognized that fundamental differences exist between single- and multi-phase equipment that may affect oversizing. As shown in Tables 27 and 28, most of the single-phase motors surveyed are used for pumps. These data indicated that several of the different motor options used for pumping applications warranted testing.

The next most significant criterion for identifying the need to replace oversized motors is the size of motors currently used for certain applications. As shown in Tables 29 and 30 for Grafenwöhr and Hohenfels, respectively, the largest motors surveyed (above 10 kW) are used to pump water; both for HVAC applications and potable water distribution. Intermediate-sized motors (between 1 and 10 kW) are typically used for pumps and to a lesser extent for fans. Furthermore, nearly all of the intermediate-sized motor/pump units are of integral (close-coupled) design. Even for smaller motors (below 1 kW), pumping applications were the most prevalent at both Grafenwöhr and Hohenfels. As would be expected, this finding reflects the heavy use of hydronic space heating and district heating as opposed to forced-air HVAC systems.

Another important criterion in evaluating the need to replace an oversized motor is duty cycle. Efficiency penalties of grossly oversized motors may not offset replacement costs for applications in which the motor is seldom used. Therefore, duty cycle, which is in part a function of building use, should be considered. As was seen previously, the building profiles with the largest motor populations included numbers 8 (Cafeterias), 11 (Heating Plant), and 35 (Gymnasium). Emphasis therefore needed to be placed on testing motors in these building profiles.

The final consideration in selecting motors for testing is motor design. Due to the test method proposed for determining motor load, which is based on the use of a tachometer, a motor shaft must be visible. Furthermore, the shaft must be accessible such that motor function or load is not affected by the test method. These limitations clearly indicate that only motors with exposed shafts can be tested. Therefore, based on a review of the videotapes, a list of motors that appeared to have accessible visible shafts was compiled. This list is presented in Table 53.

Onsite Testing

In January and February 1988, a 4-week field testing trip was conducted at Grafenwöhr and Hohenfels Army Posts in West Germany. As noted in the previous section, specific motors were selected (Table 53) for testing before the trip. This selection had already eliminated as untestable many of the previously surveyed motors. Once in the field, additional motors were found to be unavailable or extremely difficult to field test. Examples are motors in explosion hazard areas, oil burner blower motors, hermetically sealed refrigeration compressor motors, and hot water circulating pumps.

The motors tested at Grafenwöhr and Hohenfels consisted chiefly of belt-driven air compressors, refrigeration compressors, centrifugal fan applications, and direct-coupled motor pump assemblies.

Table 53

Motors That Could Be Tested
(Shafts Visible for Tachometer Measurements)*

Bldg No.	Profile	Pumps	Fans	Air Compressors
Gr ifenwohr				
129	5	2	-	-
624	9	2?	-	-
102	11	4?	-	-
210	11	3?	-	-
285	11	8?	-	-
556AS	11	4?	-	-
618	11	3?	-	-
646	11	1?	-	-
319	23/4	-	-	1
547	35	-	9	-
2060	38	-	1	-
1125	46	-	1	-
324	50	2	-	-
371	50	1?	-	-
372	50	2?	-	-
373S	50	1?	-	-
441	51	-	-	1
546	52	2	-	-
322	?	-	-	1
WP-10	?	4	-	-
Hohenfels				
1	1	-	-	(1-6?R)
9	3	-	-	1
23	7	10?	-	-
162	8	-	2	-
10	10	-	-	(2R)-(1A)
3	11	2 -10?	3	1
274	11	4-2?	-	2
320	(not 379) 11	3?	-	-
35	23	-	1?	-
88	35	-	1?	-
522	51	3	-	-
616	53 (not 16)	3?	-	-
278	54	1?	-	-

*Legend: ? = Looks to be testable but not entirely clear on video tape. R = Refrigeration compressor. A = Air compressor.

The electric motors found at both Grafenwöhr and Hohenfels are of very modern design. Most of the heating plants and related equipment were installed in 1985. The hot water circulating pumps were placed in the "untestable" category because they were completely encased and mounted directly on the pump housing. These motors were of an advanced design. In some cases, two motorized pumps were mounted on the same pump housing operating on the same pipe. Apparently, this design uses one pump as a primary and activates the second pump if the system demand for hot water exceeds the capacity of the primary pump. Newer installations have variable-speed pumps in which a variable-frequency inverter is used to vary the speed of the induction motor powering the pump. Varying the speed of the pump to regulate fluid flow in response to demand is state-of-the-art technology made possible by recent developments and microprocessor applications.

Ventilation systems were found primarily in buildings such as gymnasiums and theaters. Natural ventilation is used in most small buildings. All of the ventilation systems tested used two-speed motors for high-low ventilation control and for starting. The control system required to perform both functions is relatively sophisticated. Upon start-up for maximum speed operation, a timer is used to ensure that the motor reaches low revolutions per minute, then disconnects power for about 1/2 sec before power is applied to the high revolutions per minute winding. This ensures that power is not applied until transient and subtransient induced voltages have decayed in the high-speed winding. It also reduces starting surges in the power system. Many of the newer air compressors surveyed also use this two-speed "soft start."

Test measurements were for input current, voltage, power factor, and shaft speed. When possible, care was taken to obtain data under typical normal loading and under maximum loading.

Test Results

In total, approximately 65 motors were tested at Grafenwöhr and Hohenfels. To supplement videotape information on each test, the form in Figure 71 was prepared. Information on the motor testing from the videotapes and motor test forms were then transferred to the computer data base.

Since additional electrical power costs can be incurred due to both inefficiencies (oversized motors) and power factor, part of the test plan was to measure the motors' power factor. Table 54 summarizes the power factors for the motors tested. Typically, utilities assess penalties when the power factor for the customer is below 90 percent. In addition, lower measured power factors on an individual motor indicate that the motor is operating at low load. For typical motors, power factor decreases rapidly (below 70 percent) at loads of less than 75 percent as was shown previously in Figure 63.

As Table 54 shows, most of the motors tested showed relatively high power factor test results. Compared with nameplate power factors, many of the motors tested were in relatively close agreement with their nameplate values. When analyzed in terms of applications, the average power factor for code 1E1, HVAC central heat plant pumps, was 75 percent with a low of 39 percent and a high of 90 percent. The next most prevalent application tested was 1G, HVAC central heating plant fans. In this application, the average power factor was 63 percent with the low being 34 percent and the high being 83 percent. Although the power factor appears to be low, it should be noted that some of the motors tested were already the energy-efficient type. In addition, the applications should be examined closer. Some of the fans tested were associated with blower motors on boilers. Typical combustion air control mechanisms involve the use of dampers. As boiler load changes, so does the blower motor load. Energy-efficient alternatives require a case-by-case analysis for many of these applications. Therefore, although low power factor values were recorded, the lack of a statistically meaningful sample prevents drawing any conclusions with regard to correlating applications or building profiles with motor oversizing based on general power factor levels.

HOHENFELS: ☐	GRAFENWOHR: ☐

MOTOR TEST DATA REFERENCE

BUILDING #:______________ SHEET #:______________ OF ______________

NAME PLATE DATA

NAME PLATE POWER ____________ KW | NAME PLATE SPEED ______________ RPM

NAME PLATE POWER FACTOR COS@ ____________ | SYNC SPEED __________ RPM

PHASE VOLTAGE: RED PHASE________ BLUE PHASE________ BLACK PHASE________
(Line to neutral)

PHASE CURRENT: RED PHASE________ BLUE PHASE________ BLACK PHASE________

POWER PHASE: _________ RED KW _________ BLUE KW _________ BLK KW

POWER INPUT: ______________ KW TOTAL

REACTIVE VOLT AMPS: ______________ K VAR

TOTAL KVA: ______________ KVA

POWER FACTOR: ______________ %

MEASURED MOTOR SPEED ______________ RPM

QUICK CHECKS:

$$KW^2 + KVAR^2 = KVA^2$$

P.F. = KW / KVA
= COSINE (PHASE ANGLE)

COMPUTATIONS:

SYNCHRONOUS SPEED IN RPM - NAME PLATE RPM = FULL LOAD SLIP IN RPM
SYNCHRONOUS SPEED IN RPM - MEASURED RPM = ACTUAL SLIP IN RPM
ACTUAL SLIP (RPM) / FULL LOAD SLIP (RPM) = L
L X 100 = % OF FULL LOAD MOTOR OPERATION
L X NAME PLATE KW (HP) = LOAD ON MOTOR

COMPUTED MOTOR LOAD

1ST SPD __________ % OF RATED LOAD ____________ ACTUAL LOAD KW (HP)

2ND SPD __________ % OF RATED LOAD ____________ ACTUAL LOAD KW (HP)

COMMENTS: ____

____

____

form 4

Figure 71. Measured motor test data form.

Table 54

Power Factor Test Results

Bldg No.	Bldg Cat.	Application Code	Power Factor (%)
Grafenwöhr			
285	11	1E1	90
285	11	1E1	79
285	11	1E1	63
285	11	1E1	61
441	-	3B	46
442	3	3G	87
546	51	4H	85
546	51	4H	85
546	51	4H	61*
546	51	4H	83
546	51	3B	85
547	35	1G	61
547	35	1G	75
547	35	1G	83
547	35	1G	63
547	35	1G	75
547	35	1G	82
547	35	1G	60
2060	38	1G	91
2060	38	1E1	39
2060	38	1G	34
2060	38	1G	36
Hohenfels			
3	8	1E1	84
3	8	1E1	72
10	10	2A	58
10	10	2A	41
10	10	3G	78
88	35	1G	59**
88	35	1G	57**
88	35	1G	76**
88	35	1G	54**
162	8	1E1	72
162	8	1G	44
274	11	1E1	80
274	11	1I	71**
274	11	1I	90
274	11	1A	78
274	11	1C	35 *
274	11	1E1	86
278	-	1K	60

*No load or low load.

**Tested at highest speed.

However, some observations can be made for individual buildings from the power factor test data, specifically:

- At Grafenwöhr, building 2060 (Theater with Stage) produced motors with the highest and lowest power factors of 91 and 34 percent, respectively. At Hohenfels, motors in building 274 (Heating Plant, Coal-Oil-Fired) contained the highest and the lowest power factors of 90 and 35 percent, respectively.

- Motors with the highest average power factors of 87 and 90 percent are in building 442 (Exchange Maintenance Shop) at Grafenwöhr and in building 616 (Chlorination Building) at Hohenfels, respectively.

In addition to power factor tests, several tachometer tests were performed to determine the existence of oversized motors. Tables 55 and 56 present the tachometer test results for Grafenwöhr and Hohenfels, respectively. In total, 38 motors were tested successfully. Due to testing conditions and apparent manufacturer mislabeling of motor nameplates, some test results, upon further evaluation, were determined to be inconsistent. These tests were not included in the results of Tables 57 and 58. As can be seen from these data, several motors tested were of multispeed design. Although multispeed motor technology implies energy conservation, sizing is still an important factor in determining efficiency. The major group tested was 1G, HVAC central heating plant fans. Of the 38 tested motors, 15 were in this category. The next most prevalent categories in order included:

1E1 4 - HVAC central heating plant pumps

3G 4 - Air compressors for maintenance and repair applications

4H 4 - Cooling water pumps

2A 2 - Refrigeration compressors at central cold storage

1A 2 - HVAC central heating plant air compressors

4I 2 - Potable water pumps

1K 1 - HVAC local application water circulating pump

4G 1 - Washing water pump

2D 1 - Refrigeration compressor for local application

1I 1 - HVAC central heat plant fan

Motors ranged in size from 0.037 kW to 18.5 kW. Tables 59 and 60 list the calculated operating loads for the tachometer-tested motors. In general, more than 60 percent of the motors tested showed an operating load of greater than 60 percent. As mentioned before, motor efficiency drops dramatically at loads below 50 percent for the typical motor. This result would indicate that most of the motors tested were not significantly oversized. Of the remaining 40 percent (15 motors), seven were in category 1G, HVAC central heating plant fans. Furthermore, all of these motors were of multispeed design. This finding would indicate that these motors, as a group, have been significantly oversized or that the RPM

Table 55

Tachometer Test Results From Grafenwöhr

Measured RPM / Namepleate RPM x 100 %	Synchronous RPM	KW	Building HP	Profile Number	Motor Number	Code
96	3000	9	--	319	4	3G
100	750/1500	1.7/6.8	--	547	35	1G
100	750/1500	3.5/13	--	547	35	1G
100	1500	11		2060	38	1G
100	3000	18.5	--	3492	52	4H
101	3000	4	--	442	3	3G
101	3000	15	--	546	51	4H
101	750/1500	3/10	--	547	35	1G
101	750/1500	4/16	--	547	35	1G
101	750/1500	1.7/6.8	--	547	35	1G
101	750/1500	1.3/51.3	--	547	35	1I
101	1500	11	--	2060	38	1G
101	3000	18.5	--	3492	52	4H
102	1500	--	5	411	--	--
102	3000	15	--	546	51	4H

Table 56

Tachometer Test Results From Hohenfels

Measured RPM / Namepleate RPM x 100 %	Synchronous RPM	KW	HP	Building Number	Profile Number	Motor Code
50	750	13/3.5	--	88	35	1G
50	750	13/3.5	--	88	35	1G
51	750	1.3/5	--	88	35	1G
51	750	1.3/5	--	88	35	1G
67	1000	0.11/0.037	--	278	0	1K
80	1500	7.5	--	3	8	1E1
80	1500	7.5	--	3	8	1E1
99	1500	13/3.5	--	88	35	1G
99	1500	13/3.5	--	88	35	1G
100	1500	0.11/0.037	--	278	0	4G
100	3000	4	--	392	--	3G
100	3000	5.5	--	616	16	4I
100	3000	5.5	--	616	16	4I
101	1500	1.3/5	--	88	35	1G
101	3000	11	--	274	11	1A
101	3000	11	--	274	11	1A
101	3000	2.2	--	320	11	1E1
102	1500	--	3	10	10	2A
102	1500	1.3/5	--	88	35	1G
102	3000	3	--	274	11	1E1
103	1500	1.5	--	10	10	3G
103	1500	3.3	--	10	10	2A

Table 57

Projected Major Building Category Loads

Building No.	Category Description	Grafenwohr Loads Load type	Grafenwohr Loads kWh/mon	Hohenfels Loads Load type	Hohenfels Loads kWh/mon	Combined kWh/mon
16	Dining (Troops)	MISSION	246,000	MISSION	157,770	403,770
50	TRAINING RANGES	MISSION	225,257			225,257
48	EXT STREET LTING	LIGHTING	132,972	LIGHTING	61,365	194,337
47	INSTLTN WATER SUPPLY	MOTORS	130,465	MOTORS	60,207	190,672
8	Dining/Cafe/Snack	MISSION	130,321	MISSION	16,729	147,050
12	Hutments	LIGHTING	66,734	LIGHTING	35,272	102,006
49	AIRFIELD AREA	MISSION	57,841	MISSION	35,964	93,806
11	Heating Plt	MOTORS	37,995	MOTORS	52,271	90,266
6	Family Housing	LIGHTING	70,362	LIGHTING	18,469	88,831
6	Family Housing	MISSION	68,796	MISSION	18,058	86,855
9	Commissary	MOTORS	44,480	MOTORS	34,309	78,789
35	Gymnasium/ Rec Bldg	MOTORS	41,280	MOTORS	25,300	66,580
43	Detached Lavatory	SUPPORT	53,922	SUPPORT	4,099	58,020
16	Dining (Troops)	LIGHTING	30,707	LIGHTING	19,694	50,401
3	Motor/Tank/Repair Shop	LIGHTING	31,689	LIGHTING	6,446	38,135
4	Storage	MOTORS	24,724	MOTORS	11,796	36,520
6	Family Housing	MOTORS	28,372	MOTORS	7,447	35,819
44	Wash Facility			MOTORS	35,692	35,692
4	Storage	SUPPORT	23,777	SUPPORT	11,344	35,122
30	PX Retail/Sales	LIGHTING	26,972	LIGHTING	7,397	34,368
43	Detached Lavatory	LIGHTING	31,092			31,092
1	Administration	LIGHTING	21,324	LIGHTING	9,320	30,643
27	Bowling Center	SUPPORT	25,506	SUPPORT	4,111	29,617
35	Gymnasium/ Rec Bldg	LIGHTING	18,229	LIGHTING	11,172	29,400
6	Family Housing	SUPPORT	22,333	SUPPORT	5,862	28,196
3	Motor/Tank/Repair Shop	MISSION	22,607	MISSION	4,599	27,206
1	Administration	MISSION	18,767	MISSION	8,203	26,970
8	Dining/Cafe/Snack	LIGHTING	25,306			25,306
11	Heating Plt	MISSION	10,296	MISSION	14,165	24,461
18	Telephone Exchange	MISSION	10,847	MISSION	12,601	23,448
4	Storage	MISSION	14,970	MISSION	7,142	22,112
4	Storage	LIGHTING	14,970	LIGHTING	7,142	22,112
1	Administration	SUPPORT	15,231	SUPPORT	6,657	21,888
31	PX Branch	LIGHTING	10,114	LIGHTING	8,078	18,192
37	Rec Center/ EM Clu	LIGHTING	10,237	LIGHTING	5,349	15,586
27	Bowling Center	LIGHTING	13,791			13,791
40	Misc Sheds/Garages/ Detached Bldgs	SUPPORT	7,816	SUPPORT	5,951	13,767
27	Bowling Center	MISSION	11,590			11,590
30	PX Retail/Sales	MISSION	10,030			10,030
23	Fac Engr Maint Shop	MOTORS	9,958			9,958

Table 57 (Cont'd)

Building No.	Category Description	Grafenwohr Loads Load type	Grafenwohr Loads kWh/mon	Hohenfels Loads Load type	Hohenfels Loads kWh/mon	Combined kWh/mon
23	Fac Engr Maint Shop	MISSION	9,080			9,080
10	Cold Storage			MOTORS	9,053	9,053
51	Sewage Treatment Plant			MOTORS	8,710	8,710
15	Electronics Maint			MOTORS	7,685	7,685
25	Laundry	MISSION	7,397			7,397
2	Training			LIGHTING	7,235	7,235
45	Rock Crusher Plant			MOTORS	6,465	6,465
30	PX Retail/Sales	SUPPORT	6,336			6,336
23	Fac Engr Maint Shop	SUPPORT	5,836			5,836
35	Gymnasium/ Rec Bldg	MISSION	5,739			5,739
28	Lunch Room			MISSION	5,668	5,668
17	School	LIGHTING	5,552			5,552
3	Motor/Tank/Repair Shop	MOTORS	5,533			5,533
3	Motor/Tank/Repair Shop	SUPPORT	5,454			5,454
13	Trng Simulator	MISSION	5,116			5,116
7	Troop Housing	SUPPORT	4,905			4,905
31	PX Branch	MISSION	4,747			4,747
23	Fac Engr Maint Shop	LIGHTING	4,618			4,618
38	Theater	MOTORS	4,612			4,612
38	Theater	LIGHTING	4,585			4,585
19	Fire Station	SUPPORT	4,298			4,298
27	Bowling Center	MOTORS	4,292			4,292
31	PX Branch	SUPPORT	4,145			4,145
49	AIRFIELD AREA	LIGHTING	4,092			4,092
2	Training			MISSION	4,079	4,079
39	Class VI Store			MISSION	4,072	4,072

Table 58

Mission and Support Equipment Major Loads

Ranking by Total Connected Watts	Load Name	Audit Qty	Total Connected (W)	Est. Total Consumption (kWh/Week)
1	food service equip	407	1158521	23223
4	hot water heater	45	154000	2325
6	computer	238	74700	2289
2	boiler plant loads	16	173750	2112
3	inline tele exchange	15	154100	1862
8	coffee pot	116	57951	1814
14	air compressor	9	42070	1757
11	dryer,clothes(electric)	12	49600	1499
7	air cond	13	66800	1492
30	vend mach	58	10300	1234
24	sauna	3	16000	1213
5	washer,clothes	69	94724	1078
17	heater	30	38430	797
29	fan	41	11023	639
0	dryer,clothes(NON-elec.)	32	52640	616
9	copy mach.	41	57000	605
21	battery charger	8	23202	504
56	UPS(uninterruptible power sup)	1	2500	420
19	bowling equip	14	33080	408
22	frequency converter	2	17500	390
26	television	77	13413	364
33	ventilation fan	10	9000	294
31	tank simulators	4	10000	269
38	exhaust fan	36	5770	246
36	electronic eq	1	8000	245
39	blow dryer	2	5540	238
55	antenna	1	2600	222
35	water cooler	13	8580	209
16	craft/hobby load	8	39486	206
40	stereo	37	5500	190
28	med equip(misc)	2	11294	189
46	intercom	46	4600	150
20	printer	135	24220	132
48	cash register	46	4214	130
32	air hand dryer	7	9800	118
75	auditorium clock	1	700	114
41	video game	57	5130	108

test is not valid for this class of motor. Since other multispeed motors that were tested produced much higher calculated load factors, the test approach appears to be valid. Upon closer analysis, it seems that only those motors in building 88 (building category 35) have been oversized. This oversizing may reflect conservative design philosophies for buildings with potentially large occupancy changes such as gymnasiums and theaters.

Several motors were identified as being oversized. At Grafenwöhr, buildings 319 (Facilities Engineer Storehouse with one oversized motor), 411 (General Storehouse with one oversized motor), and 3492 (Potable Water Pump Station with one oversized motor) contain possible oversized motors. At Hohenfels, buildings 10 (General Purpose Warehouse with 10 oversized motors), 88 (Gymnasium with seven oversized motors), 274 (Heating Plant, Coal-/Oil-Fired with two oversized motors), 278 (Storage Building with one oversized motor), and 511 (Electrical Maintenance Shop with one oversized motor) have possible oversized motors.

The other oversized motors identified were in categories 3G(3), 2A(2), 1E1(1), and 1K(1). The oversizing in category 3G represents the brake horsepower requirement for air compressor loads and the varying loads, depending on air pressure requirements and tank pressures. Oversizing in the remaining categories should be examined on a case-by-case basis. Additional surveying and testing would be required to determine the statistical significance of these motor load test results.

Table 59

Calculated Load Test Results From Grafenwöhr

Calculated Load (%)	kW	HP	Building Number	Category Number	Motor Code
13	9	--	319	4	3G
28	--	5	411	--	--
60	18.5	--	3492	52	4H
65	1.7/6.8	--	547	35	1G
68	3/10	--	547	35	1G
69	1.3/51.3	--	547	35	1I
70	4/16	--	547	35	1G
73	4	--	442	3	3G
73	15	--	546	51	4H
77	15	--	546	51	4H
82	11	--	2060	38	1G
84	3.5/13	--	547	35	1G
85	1.7/6.8	--	547	35	1G
88	18.5	--	3492	52	4H
90	11	--	2060	38	1G

Table 60

Calculated Load Test Results From Hohenfels

Calculated Load (%)	kW	HP	Building Number	Category Number	Motor Code
13	13/3.5	--	88	35	1G
17	13/3.5	--	88	35	1G
18	1.3/5	--	88	35	1G
29	13/3.5	--	88	35	1G
30	1.3/5	--	88	35	1G
33	13/3.5	--	88	35	1G
36	1.3/5	--	88	35	1G
42	--	3	10	10	2A
43	3.3	--	10	10	2A
46	1.5	--	10	10	3G
47	3	--	511	15	2D
53	0.11/0.037	--	278	0	1K
56	3	--	274	11	1E1
60	11	--	274	11	1A
62	1.3/5	--	88	35	1G
64	2.2	--	320	11	1E1
65	7.5	--	3	8	1E1
68	11	--	274	11	1A
72	7.5	--	3	8	1E1
72	0.11/0.037	--	278	0	4G
86	5.5	--	616	16	4I
87	4	--	392	3	3G
87	5.5	--	616	16	4I

9 ENERGY CONSERVATION OPPORTUNITIES (ECOs)

Using the building category consumption data and audit/survey information presented in the previous chapters, USACERL identified potential energy conservation opportunities (ECOs) for general building categories and specific loads at the 7th ATC. In addition to being presented as possible opportunities for Grafenwöhr and Hohenfels, the suggested actions can serve as an example of the process by which consumption projections can point to numerous ECOs.

Equipment and installation/retrofit cost information related to potential conservation actions was *not* collected during this project. Therefore, implementation costs are generally not included when potential energy savings are specified.

Building Category Loads

Using the projected monthly kilowatt-hours for lighting, motors, mission equipment, and support equipment loads *in each building category*, prime targets for ECOs were identified. Table 57 shows the loads at Hohenfels and Grafenwöhr which were projected to use more than 4000 kWh/month. This section describes different energy-reducing options for the various loads.

Troop Dining Mission Equipment

This equipment is projected to use about 17 percent of the total installation electricity (kWh). From the building audit information, it is estimated that one-quarter of the 17 percent (or 4 percent of installation-wide) is used by cooking ovens in mess halls. In addition to the kilowatt-hour usage, troop dining mission equipment's effect on projected kilowatt demand at 1300 hours on weekdays is greater than 200 kW at both Hohenfels and Grafenwöhr.

One potential ECO is to convert troop cooking equipment to gas equipment. If use of gas for ovens is feasible, additional consideration should be given to using gas to generate the steam required for steam kettles, dishwashing, and domestic hot water.

Another possibility (with, at present, unknown potential) is the use of microwave ovens for some foods. Exploring the potential for microwave ovens would likely require cooperative efforts from food preparation experts (possibly available through microwave oven manufacturers) and Army personnel responsible for dining facilities.

Two of the major loads are grills and refrigerators/freezers. It is important that these appliances be operated efficiently. Grills that have sectionalized controls for heating only a portion of the grill area can permit the operator to energize only the section needed. Nearly empty refrigerators/freezers lose more cooling during a temporary opening of the compartment door than one which is packed full. Frost buildup inside freezer compartments causes the refrigeration unit to run longer to reach the desired compartment temperature. See *Commissary Motors* below for refrigeration system ECOs that could also apply to dining facilities.

Training Range Mission Equipment

These loads consist mainly of target heaters. Ranges are used day and night with a few specified shutdown hours each day. Heater on/off control is the main power switch. Since power to targets is needed for maintenance during shutdown hours, it is common for power to be on most of the 24-hr day.

Local engineers at Grafenwöhr are very much aware of the electricity used for target heaters and have considered a variety of operational changes to reduce heater "on" time. Ideas for operational changes which affect on time during periods close to or during range operating hours have met with resistance from range users. Any changes that have the slightest potential to further reduce target temperature differential (which provides visibility to heat-seeking weapon viewfinders) have been refused. The Grafenwöhr DEH is continuing efforts to find an economical means for turning off target heaters during maintenance hours while simultaneously leaving electrical power on to target movers (needed by maintenance personnel). An option being considered is a switch located at each target heater to be controlled by either a control wire (if available in the existing control cables to targets) or radio signal control.

The Grafenwöhr personnel responsible for the training ranges are in the process of reviewing alternative target systems from commercial vendors. One attractive system from an energy viewpoint uses a material that requires no heating. A possible drawback is that the material provides a negative (reverse image) target which may or may not be acceptable from a training realism viewpoint. (The current system has several weaknesses with regard to realism.) While conceding that mission performance takes priority when evaluating target systems, a life-cycle cost approach (including energy) should be considered when evaluating the maintenance/operating performance of new target systems.

The Army Agency responsible for training devices research (PMTRADE--Project Manager for TRAining DEvices, Orlando, FL) is also considering various target systems. A wide variety of ideas for providing a "viewable" target has been introduced from many sources. Some ideas (including several with obvious shortcomings) are:

- Infrared signal reflected off of target
- Target material painted with chemical, heat reaction triggered by daylight
- Steam heat system (underground, direct spray or indirect heaters)
- Aimable laser beam at targets
- High-watt instantaneous heater at standing target (vs. present low-watt constant heat-down target).

One interesting method (that requires no heating energy) currently being examined is a paint-on type of coating that makes the targets visible. One drawback is that visibility is directional; the viewer must be at the proper angle from the target in order to view it. Some trial usage is underway in the United States.

With electrical consumption for all of the Grafenwöhr training ranges estimated at more than 4 million kWh/year, there is large potential for energy savings. However, the engineering requirements to realize the potential savings are not trivial, and responsibility for resolving the problems extends beyond the local DEH into other directorates and Army agencies.

Exterior Lighting

Exterior lights are projected to consume more than 6 percent of the total installation kilowatt-hours at both Grafenwöhr and Hohenfels. The audit showed that most exterior lighting uses high- intensity discharge (HID) type lamps which are more efficient than fluorescent or incandescent lights. More specifically, most of the HID lamps are mercury vapor lamps, with a lesser quantity of other types such as high-pressure sodium, metal halide, and others. Typical watt rating for the mercury vapor lamps was assumed to be 250.

One way to reduce exterior lighting energy is to use currently available (but not yet commonly found) hardware to dim HID lamps. A 250-W mercury vapor lamp dimmed to 45 to 50 percent of lumen output requires approximately 60 percent of the original lamp input power. (Input to output for other wattages and types of HID lamps will differ slightly.)

Applications to date for this hardware have been primarily in aircraft aprons, parking lots, and numerous indoor facility types. Some of the available equipment offers a controllable (bilevel) dimming ballast for each fixture or the use of centrally located ballasts (remote to the fixture) if distances are not too great. Manufacturers of dimming ballasts claim that use of their devices helps avoid some of the problems (e.g., lamp instability, shortened equipment life, harmonics) that can occur with inline dimmers which attempt to dim conventional ballasts.

One dimming scenario for Army installations is to have exterior lighting at full power from dark until 2300 and at 55 percent power (45 percent light output) thereafter. In areas where security or safety is a concern, motion detectors can be used to return lighting to full bright when activity is present. For installations such as Hohenfels and Grafenwöhr, where exterior lighting comprises approximately 6.7 percent of the electricity use, if half of the exterior lighting were dimmed to 55 percent power for three-fourths of the night hours, the installation electrical consumption would be reduced by about 1.2 percent.

Other com .only recommended energy conservation activities include using lower wattage lamps in existing fixtures (where hardware permits) and replacing fixtures and/or lamps with more efficient ones (where hardware permits lamp substitutions). The following system types are listed from generally less efficient to more efficient:

- Incandescent
- Fluorescent
- Mercury vapor
- Metal halide
- High-pressure sodium
- Low-pressure sodium.

Installation Water Supply Motors

Neither the manufacturers' product information nor the field information obtained in the motor survey were specific enough to permit a determination of the efficiency level of the existing water pumping equipment. Operation of water pumps should be scheduled during off-peak rate hours to the extent possible and should be avoided during peak demand hours. This practice is currently almost always followed at Grafenwöhr and Hohenfels.

Hutment Lighting

Lighting comprises most of the building's installed equipment in hutments. (Some troop units may bring plug-in type appliances which were not accounted for in the limited audit.) Lighting loads found during the audits consisted of 79 percent 1 by 4 fluorescent fixtures (1 lamp, 4-ft length), 17 percent incandescent, and 4 percent exterior lights.

Family Housing Lighting

It is estimated that nearly half of the lighting in family housing is commonly found incandescent bulbs (typically 60 to 100 W). If just half of these incandescents were replaced with compact fluorescents, the result would be a 6 percent reduction (≈50,000 kWh/year projected at Grafenwöhr) in family housing lighting.

Commissary Motors

The main load in this group is refrigeration compressors. Inferring from the apparent age and environmental conditions surrounding some compressor units found in the audit, engineering concepts could be applied to improve the efficiency of some units.

For new construction, major renovation, or routine replacement, consider rotary-type compressors which are claimed to be 15 percent more efficient than the most efficient reciprocal-type compressor. Energy-saving steps for modifying existing refrigeration systems include (1) improving ventilation of heat exchangers (condenser and evaporator) and (2) increasing exchanger thermal capacity (by making it longer) to extend the time available for heat transfer. The latter step, increasing exchangers' capacities, may be a simple alternative to using variable-speed compressors because it allows a relatively large compressor to run efficiently at low heat load, yet still handle peak loads. Both steps are based on the fact that efficiency is inversely proportional to the temperature difference between condenser and evaporator.

One way to improve the condenser temperature (and therefore system efficiency) is to reduce the ambient temperature surrounding the condenser. For new systems, this implies locating the condenser properly (possibly outdoors). For existing systems, make sure the area where condensers are located is well ventilated to reduce the ambient temperature. It is possible through careful design to incorporate more sophisticated techniques for reducing condenser temperature by using heat reclamation and subcooling. Reclaimed heat can be used for other purposes.

During the audit, several compressor locations were less than ideal. Compressors were located in mechanical rooms with considerable heat buildup. At several of the outdoor locations, building occupants had erected makeshift walls (of canvas) around the compressors.

The maintenance counterparts to improving exchanger ventilation and increasing exchanger capacity are (1) prevent decreases in ventilation of exchangers and (2) prevent decreases in exchanger thermal capacity. At the evaporator, this means to avoid excessive buildup of frost on the coils which decreases efficiency. At the condenser, the coil must be free of dirt and debris that can block air flow. Also, the system must maintain a proper level of coolant.

For packaged refrigeration units with all system components in one cabinet, many of the same concepts apply. Ambient temperature affects the efficiency of packaged units. Using a common European test for electricity consumption of refrigerators, it was determined that lowering the ambient temperature by 5 °C will result in electricity savings of about 30 percent. Ambient temperature could be reduced for the unit by increasing general area ventilation or by more specifically directed ventilation or placement of the refrigeration unit.

Combination refrigerator/freezer units (U.S. style) have inherent inefficiencies. It is thermodynamically inefficient to create the +5 °C temperature for the refrigerator through a cycle reaching -20 °C as required by the freezer. Additional inefficiency occurs from the increased frost buildup when the freezer section is located in the compartment with the refrigerator section. For the combined refrigerator/freezer section, the rate of frost buildup is typically 10 times higher.

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Gymnasium/Recreational Building Motors

Of the projected consumption, approximately 90 percent of the motor load is for ventilation system motors. (See the section in Chapter 8 concerning possible oversized motors in gymnasium ventilation systems.) In large gym ventilation systems where one switch might control several fans, system controls being operated manually by the facility manager were not always marked to clearly indicate the various operating functions as intended by the system designer. Inadvertent improper operation of these large ventilation systems could contribute not only to unnecessary electrical consumption, but also to heating energy waste.

Detached Lavatory Support Equipment

This equipment consists chiefly of heat system fans and bathroom-type exhaust fans that could be controlled for automatic shutoff by using timers, occupancy sensors, humidity sensors, or other devices. Many of the detached lavatories at Grafenwöhr have already received major retrofits.

Troop Dining Lighting

The loads observed during audits were approximately two-thirds fluorescent lighting, with the most common size being 2 by 4 (2 lamps, 4-ft length) fixtures. For fixtures in the eating area, fluorescent dimming controls could reduce electrical use at times when lower illumination levels are acceptable (and maybe even preferable). Five percent or more of the lighting was incandescent lamps with potential for replacement by lower wattage compact fluorescent lamps.

Equipment Loads

Table 58 summarizes the mission- and support-related electrical loads audited during the study. The loads shown are those estimated to have a consumption greater than 100 kW/week and are listed in order of decreasing estimated weekly consumption (far right column, kWh/week). The first column shows how the load would rank when considering its total electrical watt rating, with the fourth column showing the value. As can be seen, the estimated weekly consumption depends not only on the rating of the load but also on other factors such as end-use. The third column (Audit Qty) shows the number of times that that load was found during the electrical audits.

Food Service Equipment

This category represents the number one load found and includes: refrigerators and freezers, ovens/stoves, grills, microwaves, dishwasher loads, and miscellaneous food preparation equipment. ECOs are as discussed above for Dining Mission Equipment and Commissary Motors.

Hot Water Heaters

Large hot water heaters could have timers installed to automatically shut-off the units during selected hours. Typical heaters (5-L, 2000-W) can be operated on a commonly available economy setting which lowers the maintained water temperature.

Computers

This equipment includes PCs and terminals. An interesting aspect of electricity consumption is the possibility of harmonic distortion caused by the use of computers and other electronic loads, leading to a real (the loads need more power to perform the same tasks) or apparent (the meter reading is incorrect) inflation of their consumption. This phenomenon is currently being researched at USACERL.

The most obvious method of reducing computer energy consumption is to ensure that personnel are deenergizing them when not in use. In some cases, this practice may have the additional benefits of increasing equipment life and data security. In other cases, it may not be feasible due to the vital role the computer may play.

In the future, PCs may have lower energy requirements as a result of lower wattage displays (such as flat-panel displays) to replace cathode ray tubes (CRTs). Also, as computer chips continue to become more condensed in size, input power requirements (and therefore energy consumption) may necessarily be reduced to avoid internal overheating and destruction of the chips.

Miscellaneous

The idea of dividing electrical circuits into critical and noncritical circuits, allowing the noncritical circuit to be deenergized at night, might aid in reducing the overall consumption of new buildings. This design would incur additional wiring costs but could provide a useful means of control for Energy Management and Control Systems (EMCS). An economic evaluation of this concept is needed.

Night Baseline Consumption ECOs

As was shown previously, night baseline consumption is a significant portion of electrical usage. For example, at Hohenfels, nightly consumption between 2230 hours and 0630 hours accounts for 25 percent of the total electrical usage. One output of the computer program described in Chapter 3 is a list of buildings projected to be the major consumers during one selected night hour. For Hohenfels and Grafenwöhr, where approximately 18 percent of the building area has been audited, more specific information, namely the list of electrical loads found during the audit, is available. Each load was labeled subjectively as to whether it could potentially be shut off at night. Six night hours of kilowatt usage were summed for each load labeled as having potential for night shutoff.

At Hohenfels, for example, where the night baseline averages about 1000 kW, the loads identified for shutoff were projected to be about 40 kW. Over a 6-hr night shutoff period, this amounts to 240 kWh/night (87,000 kWh/year). While this quantity is relatively small, it must be remembered that the 40 kW of identified loads are located in only 20 percent of the total installation building area that was audited.

The main loads in 40 kW of load identified for possible shutoff were air compressor units, exhaust ventilation, interior and exterior building lighting, domestic water heaters, and vending machines. Some of these loads could benefit from on/off timers. Exterior lighting could be reduced through dimming hardware. With other, smaller loads for which hardware costs are prohibitive, building personnel may be needed to turn equipment off at night.

10 SUMMARY OF FINDINGS

Meter data and building audit information from Grafenwöhr and Hohenfels have been compiled into a data base of "typical" building consumption for various building categories. Meter data were selected from the 120+ metered buildings at Hohenfels and the 70+ metered buildings (with EMCS connected meters) at Grafenwöhr. Also used were estimated ratings and usage of typical building equipment and appliances. The data base consists of projected electricity usage 24-hr profiles for each defined building category. Army category codes as enumerated in AR 415-28 reflecting building function were used to group buildings into building categories. The 24-hr profile developed for each building category is further divided into four subprofiles for lighting, motors, mission equipment, and support equipment. Separate weekday and weekend profiles/subprofiles were developed for each building category.

Using the data base in conjunction with a user's list of buildings, it is possible to obtain various breakouts of projected electrical use. For most building categories, the projections are obtained easily by multiplying the data base numbers by the appropriate building area. For several utility loads such as exterior street light which do not relate directly to individual building area, other methods for projecting consumption were used (e.g., multiplying by the total community building area). To make the otherwise static projection numbers match actual data more closely, monthly multipliers were developed and used to make projection adjustments appropriate for the month.

As an initial check of the ability to project installation-wide electrical consumption, projected numbers were compared with actual meter data from Hohenfels and Grafenwöhr. At Hohenfels from 1986 to 1988, the difference between projected installation-wide monthly and metered kilowatt-hours ranged from -10 to +20 percent per month. (A negative number indicates projected was less than actual.) At Grafenwöhr, the difference between projected and actual monthly kilowatt-hours ranged from -14 to +16 percent per month during 1986 through 1988. The profiles can also be used to project peak kilowatt demand. (Note that projections are intended to represent a typical day and therefore might be expected to produce a lower peak demand value compared with the single highest peak interval of the month.) At Hohenfels for 1988, the difference between projected monthly peak kilowatt demand and actual ranged from -13 to +3 percent. At Grafenwöhr from 1986 to 1988, the difference between projected monthly peak kilowatt demand and actual demand ranged from -22 to +8 percent. In addition to comparing total monthly kilowatt-hours and monthly peak kilowatt demand, projected and actual 24-hr profiles were compared for several calendar months of data (see Figures 6, 7, 10, and 11).

Using the building list for the Amberg community (fewer than 100 buildings), projection numbers were compared with installation-wide electrical usage. At Amberg for a 1-year period ending in mid-1989, the difference between projected monthly and actual kilowatt-hour use ranged from -5 to +9 percent per month. At Amberg for the same time period, the difference between projected monthly and actual peak kilowatt demand ranged from -32 to -11 percent.

This method of making electrical consumption projections was developed as an informational tool to guide future energy conservation efforts. Another desirable tool in managing electrical energy is the ability to easily detect alarming trends in electrical meter data without requiring hours of data analysis. Toward this end, several types of data checks were defined and detection algorithms developed.

Algorithms were developed for detecting the following trends in a building's monthly meter data: (1) unexpected seasonal trends in the absence of air-conditioning systems and electric heating; (2) growth trends, both long- and short-term; (3) extreme variation from month to month; (4) a reasonable consumption level compared with projected consumption for this type of building.

The abilities to project electrical consumption for a list of buildings and to detect meter data trends are both being developed into a PC-based program for field use. An initital version of the program was completed in March 1990.

Consumption projection outputs from the PC program will be a group of reports that can be used to target major electrical usage areas for energy conservation. Using these projection outputs along with electrical meter data, the electricity usage at both Hohenfels and Grafenwöhr was evaluated.

At Hohenfels, monthly kilowatt-hour usage meter data from several years indicate a trend in which 15 to 20 percent more kilowatt-hours per month were used during October through March than in May through September. April's average fell between the high and low months. Total electricity costs (including demand charges) were approximately 1.47 million DMarks in 1987, for example. For recent years (1981-87), demand charges have averaged 30 percent of total electricity costs.

When considering the potential for savings through peak demand reduction, it is important to evaluate demand trends. At Hohenfels, more than 80 percent of months constituting one of the two high months (which determine annual billing demand) occurred from November to March. More than half of the high demand months in recent years at Hohenfels have occurred in November or December. Several high demand months occurred unexpectedly in May and July. Another demand trend of interest is the extremity between monthly demand peaks. Averaging 7 years of Hohenfels data indicates that, typically, peak shaving 100 kW of demand would require peak shaving action during 4 months of the year. For a more detailed examination of Hohenfels' peak demand, data indicating each 15-min interval demand for the entire months of November 1988 and January 1989 were obtained. For 100 kW of demand peak shaving, November 1988 would have required action during 4 days. In January 1989, 100 kW of peak shaving would have required action on 8 days. On the days requiring peak shaving action, the number of 15-min intervals affected varies from day to day. The Hohenfels demand curve is relatively flat between 0700 and 1700 hours each weekday. Therefore, attempts to shave peaks by more than 200 kW would require, on some days, constant load shedding from 0700 to 1700 hours.

Electrical consumption at Hohenfels was also examined by using the projection capabilities developed in this study. These consumption projections are based on the Hohenfels building list. Projection numbers indicate that the top six building categories account for more than 50 percent of the Hohenfels monthly kilowatt-hours. These building categories (with their percent of total) are:

- Troop Dining (20 percent)
- Heating Plants (8 percent)
- Exterior Lighting (7 percent)
- Installation Water Supply (7 percent)
- Family Housing (6 percent)
- Gym/Recreational Buildings (5 percent).

Projected kilowatt-hours also indicate that electrical consumption is approximately 25 percent nighttime baseline, 50 percent daytime baseline, and 25 percent daytime on-peak use. Other interesting consumption projection information for Hohenfels was presented in Figures 22 through 32.

At Grafenwöhr, monthly kilowatt-hour meter data from several years indicate a trend in which 15 to 20 percent more kilowatt-hours per month were used during October through March than in May through September. April's average fell between the high and low months. Total electricity costs (including demand charges) were approximately 3.5 million DMarks in 1987, for example. For recent years (1981-87), demand charges have averaged 27 percent of total electricity costs.

When considering the potential for savings through peak demand reduction, it is important to evaluate demand trends. At Grafenwöhr, more than 90 percent of months constituting one of the two high months (which determine annual billing demand) occurred from November to March. More than 40 percent of the high demand months in recent years at Grafenwöhr have occurred in December or January. Only one high demand month occurred (unexpectedly) in June. Another demand trend of interest is the extremity between monthly demand peaks. Grafenwöhr data indicate that, typically, peak shaving 100 kW of demand would require action in 2 to 3 months of the year.

For a more detailed examination of Grafenwöehr's peak demand, data indicating each 15-min interval demand for November 1988 and January 1989 were obtained. For 200 kW of demand peak shaving, November 1988 would have required action during 7 days. In January 1989, 200 kW of peak shaving would have required action on 3 days. On the days requiring peak shaving action, the number of 15-min intervals affected varies from day to day. The Grafenwöhr demand curve is relatively flat between 0700 and 1700 hours each weekday. Therefore, attempts to shave peaks by more than 400 to 500 kW would require, on some days, constant load shedding from 0700 to 1700 hours.

Electrical consumption at Grafenwöhr was also examined by using the projection capabilities developed in this study. These consumption projections are based on the Grafenwöhr building list. Projected numbers indicate that the top five building categories account for more than 50 percent of the Grafenwöhr monthly kilowatt-hours. These building categories (with their percent of total) are:

- Troop Dining (20 percent)
- Training Ranges (11 percent)
- Family Housing (10 percent)
- Dining/Cafe/Snack Bar (8 percent)
- Exterior Lighting (7 percent).

Projected kilowatt-hours also indicate that electrical consumption is approximately 23 percent nighttime baseline, 56 percent daytime baseline, and 21 percent daytime on-peak use. Other interesting consumption projection information for Grafenwöhr was presented in Figures 40 through 50.

A lighting survey was conducted at Hohenfels and Grafenwöhr in June and July 1988. A total of 76 buildings (11 percent of the installations' building area) was included in the general survey. From the survey, 54 percent of the building lighting was 2 by 4 fluorescent fixtures (2 lamps, 4-foot length) or 1 by 4 fluorescent fixtures. The survey found only 4.6 percent of spaces with lights on while the space was unoccupied. (The 4.6 percent does not include allowance for spaces that might have been vacated only momentarily.) In 3.6 percent of the spaces, occupants were working with the lights off.

The lighting survey included more detailed information on 89 of the spaces chosen at random from the 76 audited buildings. The auditor rated 24 percent (of the 89 spaces) as having poor wall and/or ceiling reflectivity for lighting; 32 percent could use task lighting to reduce general lighting and 14 percent had potential for using existing daylighting.

For various kinds of lighting control, the auditor indicated (using subjective judgment) whether the potential existed for reducing energy by improving control hardware. Each of the four control options considered (time control, area switching, light level switching to match task, occupancy sensors) scored 44 percent or higher, indicating the percentage of spaces where that particular control option could reduce electrical consumption due to lighting use. Footcandle measurements were taken in the 89 audited spaces. Of the office and functional (working) spaces, 18 percent had footcandle measurements that indicated possible overlighting compared with Army lighting standards. However, due to the possible effects of daylighting on footcandle readings and the subjective judgment in selecting an appropriate footcandle standard for each space, the 18 percent figure is of questionable reliability. For the 89 audited spaces, the approximate watts of lighting per square foot of space (called power density) was calculated and compared with proposed Voluntary Building Performance Standards from DOE. Some 36 percent of the spaces exceeded the DOE standard for power density. However, since the DOE standard is intended for future new buildings and no determination was made as to how close existing building spaces should be to the standard, no judgment was made concerning the appropriateness of the space power densities.

The use of electric motors at Hohenfels and Grafenwöhr was evaluated based on a field audit, manufacturers' information, and limited field testing. The field audit provided information on the location (building function) of the motor population, the different applications, and the size distribution of motors. Of the motors audited, the building categories containing the most motors were heating plants, gyms/recreational facilities, and dining facilities. The assessment of applications indicated that HVAC systems used 75 percent of the motors and 40 percent of total kilowatt load. Within HVAC systems, pumps and fans comprise 46 percent and 42 percent, respectively, of the kilowatt load. The other major application category, pumps (non-HVAC), constituted 45 percent of the total kilowatt motor load. The motor size distribution indicated that 31 percent at Grafenwöhr and 48 percent at Hohenfels are larger than 1 kW.

Motor information was requested and obtained from many manufacturers of the motors being used at Hohenfels and Grafenwöhr. The objective in collecting this information was to make a direct comparison between the efficiency of the motor models found in the field and the latest, most efficient models available. Some general discussion of motor efficiency and the use of variable-speed drives to improve efficiency is found in Chapter 8.

Manufacturers' information was obtained and reviewed but found insufficient to accomplish the original objective. Efficiency data usually were not provided by manufacturers. Also, matching nameplate models to brochure models proved to be nearly impossible due to situations such as missing nameplate information, illegible nameplates, and changing motor models and model lines over time.

Although the attempt to identify specific field-identified motor models for replacement was unsuccessful, economic analysis steps for evaluating motor replacement are discussed in Chapter 8. Using these steps with some economic assumptions, several example cases of motor replacement were considered. For the economic assumptions made, example case 1 demonstrated a situation where, for motors of 5 to 200 HP that required replacement, higher efficiency motors were clearly the more economical choice over standard efficiency motors. Larger high-efficiency motors produced greater savings. Example case 2 demonstrated a situation where, for motors of 5 to 100 HP, replacement with a higher efficiency motor was justified by cost savings whereas, for a 200-HP motor, replacement was not justified. Example case 3 dealt with the issue of oversized vs. correctly sized motors. A case was demonstrated for which it was more economical to purchase and operate a 10-HP motor at 50 percent load than a 5-HP motor at 100 percent load. This result did not remain true at larger horsepower ratings. Example case 4 demonstrated a situation where, for various horsepower ratings, higher efficiency motors were more economical than standard efficiency motors for load conditions of 50 percent, 75 percent, and full load. The economic advantage of the high-efficiency units was greatest at full load. Analysis of these example cases was facilitated by the development of a spreadsheet to automate the calculations.

Field testing was performed on 65 motors. The primary objective was to identify oversized motors. A general discussion of motor testing is found in Chapter 8. Most of the motors found at Grafenwöhr and Hohenfels were very modern, with many having advanced designs. Techniques such as parallel motors and multispeeds were used to match load requirements. Measurements used to identify possible oversized motors were low power factor readings and low calculated load based on tachometer readings. Several apparently oversized motors were discovered in large ventilation systems (typically found only in gymnasiums and theaters at Grafenwöhr and Hohenfels) and in older refrigeration compressors. A few other seemingly isolated cases of potentially oversized motors were identified.

Using the electrical consumption projection capabilities developed along with the lighting and motor evaluations, potential ECOs were identified. These were presented as potential ECOs to evaluate and as an example of how the projection information can help provide a perspective leading to ECOs. Potential ECOs were suggested for various building category loads. For example, troop dining facilities may need to evaluate the use of natural gas to replace electricity for cooking equipment. At an Army-wide level, energy conservation measures could be included in training for dining facility personnel. This training might present improved cooking techniques and equipment (e.g., microwave ovens), with cooperative assistance possibly available from equipment manufacturers. The decision to purchase new dining facility equipment should include energy in the life-cycle cost evaluation. At the local level, improved operation of the major appliances (grills and refrigerator/ freezers) can greatly affect energy consumption.

For training range target heating (where energy conservation is justifiably secondary to mission), energy emphasis at the proper command level might influence the decision between various target systems of otherwise equal capabilities. Various new target systems are currently being evaluated for Army use.

To reduce consumption of exterior lighting systems, dimming could be considered. Several U.S. companies are currently marketing dimming equipment for HID-type lamps and fixtures. Many exterior lights on Army installations, which might cause objections if turned off, could be dimmed during the middle of the night.

For hutment lighting, which consists mainly of 1 by 4 fluorescent lamps, using more efficient lamps of lower wattage could save electricity.

To reduce commissary motor loads, equipment selection during new construction is important. For example, rotary-type compressors are claimed to be 15 percent more efficient than the most efficient reciprocal compressors. For existing older equipment, retrofits using advanced techniques such as heat reclamation and subcooling may provide ECOs.

Other potential ECOs were discussed in Chapter 9.

11 CONCLUSIONS AND RECOMMENDATIONS

USACERL has evaluated electrical energy consumption for the 7th Army ATC in West Germany in an attempt to identify ECOs. A data base was developed using available meter data. Chapter 10 summarizes the results of this project.

The building consumption data base developed during this project provides interesting profiles of installation electrical consumption. It is as yet unproven in its ability to provide reasonable numbers at a wide range of USAREUR installations. The monthly meter data check algorithms also are unproven in the field. If the algorithms could be validated, suggested refinements include checking data hourly (instead of monthly) for meters connected to EMCS units.

The computer program currently being written to project electrical consumption and check monthly meter data has potential as a tool for electrical energy management. The program could benefit from pilot testing at other installations to obtain feedback on its usefulness. It could then be modified to better meet users' needs. Possible future program improvements might include linking the currently static data base to the input meter data being entered, allowing automatic data base updates.

From the review of Hohenfels and Grafenwöhr demand profiles, peak shaving actions are possible (and desirable), but will be affected by the relatively flat shape of the demand curves during the daytime. The evaluation results, particularly the projections in Figures 22 through 32 and 40 through 50, can be used by the DEHs at Hohenfels and Grafenwöhr for direction in targeting ECOs.

One notable electrical usage trend at Hohenfels and Grafenwohr was the high consumption of troop dining and, in general, all food preparation facilities. These facility types consumed more than one-fifth of the installations' electrical energy. It is recommended that these facilities at Hohenfels and Grafenwöhr be targeted for additional evaluation as to the applicability of the potential ECOs mentioned in Chapter 9. Also, if this usage trend can be verified as typical for USAREUR communities, research into improved facility design, advanced food preparation techniques, and optimal operation of dining facilities could prove beneficial at both USAREUR and Army-wide.

The lighting survey verified that lighting energy conservation in buildings should be concentrated heavily on the 4-ft fluorescent fixture. Results showed that occupants are conscientious about turning lights off in unoccupied spaces. Although the survey footcandle measurements and power density calculations were not extensive enough to determine lighting trends, the DEHs can use the footcandle and power density data to compare lighting systems in various spaces and identify potential improvements. Further, the general survey and calculation methods can serve as example procedures for installation energy coordinators who would like to perform their own surveys.

Motor usage at Hohenfels and Grafenwöhr provides only isolated opportunities for conservation. Much of the equipment is relatively late model and state-of-the-art. Motor conservation opportunities at these communities might best be detected by locating old equipment rather than concentrating on the major users specified in this report. Other installations may find the usage patterns identified here helpful in targeting conservation areas. One area with potential for improvement is in large HVAC systems typically found in gymnasiums and theaters. Several instances of possibly oversized motors were detected. Also, these systems permitted control by building operators but the control panels did not clearly indicate how they were to be operated for energy efficiency. In addition to electrical energy, heating energy could be greatly affected by the way in which these systems are operated.

The data base created in this study was compiled using a minimal amount of data. If the future use of the data base warrants improvements, more data could be incorporated. Also, only Army building category codes found at Hohenfels and Grafenwöhr were defined. Other building types may need to be defined or included with the currently defined building categories.

METRIC CONVERSION FACTORS

1 ft	=	0.305 m
1 sq ft	=	0.092 m^2
1 HP	=	0.75 kW
1 kWh	=	3.6 MJ
1 rpm	=	0.105 rad/sec

APPENDIX A:

DEFINED BUILDING CATEGORIES

ARMY CATE-GORY CODE	BLDG CATE-GORY NO.	ARMY CATE-GORY CODE	BLDG CATE-GORY NO.	ARMY CATE-GORY CODE	BLDG CATE-GORY NO.	ARMY CATE-GORY CODE	BLDG CATE-GORY NO.
12310	20	21470	40	61050	1	74034	35
12320	20	21630	0	71141	6	74040	36
12470	0	21710	15	71142	6	74041	36
12475	0	21870	4	71143	6	74047	16
12530	22	21883	4	71144	6	74048	16
13120	46	21890	4	71145	6	74050	31
13160	46	21910	23	71410	40	74051	8
13180	18	21920	23	71420	40	74052	20
13315	49	21922	23	72111	7	74053	30
13320	49	22930	45	72120	7	74054	23
13340	49	41130	4	72140	7	74055	4
13360	49	42210	4	72180	7	74056	31
13450	49	42215	4	72210	16	74057	31
13615	49	42230	4	72320	43	74060	28
14110	49	42235	4	72321	43	74062	8
14111	49	42270	4	72330	1	74065	33
14112	49	42280	4	72350	40	74066	33
14131	49	42281	4	72360	40	74067	33
14132	49	42283	4	72410	7	74068	37
14133	49	43230	10	72411	7	74069	35
14170	40	44210	4	72510	12	74074	33
14180	40	44220	4	73010	19	74076	38
14181	1	44221	40	73015	7	74078	32
14182	1	44222	40	73017	24	74079	0
14183	1	44223	40	73018	24	74084	39
14184	1	44240	40	73019	24	74086	35
14185	1	44250	40	73030	25	75025	0
14191	1	44260	40	73045	17	75061	0
17120	2	44261	40	73047	17	81160	0
17122	40	44262	40	73048	17	81320	0
17130	2	44270	4	73055	40	81321	40
17160	21	44271	4	73070	40	82110	11
17170	0	44275	4	73072	41	82120	11
17182	13	44286	0	73075	43	83110	51
17971	40	54010	5	74006	26	83120	0
21110	49	55010	5	74011	27	83230	51
21112	49	55020	5	74013	28	84120	0
21210	14	61011	1	74014	29	84121	0
21220	14	61021	1	74020	30	84131	47
21410	3	61022	1	74021	9	84141	47
21411	3	61023	1	74022	32	84150	47
21412	3	61024	1	74025	2	84220	47
21413	3	61026	1	74026	32	84460	0
21420	3	61027	1	74030	35	84520	47
21421	3	61028	1	74032	7	87170	0
21456	44	61041	1	74033	34	87230	42
						87235	1

APPENDIX B:

BUILDINGS AUDITED AT HOHENFELS AND GRAFENWÖHR

AUDITED BLDGS AT HOHENFELS & GRAFENWOHR

COMU NITY	BLDG NO.	Building/Facilit	AREA
HOH.	H-15	AAFES audio vis	3436
HOH.	1	commissary	7066
HOH.	1	post hq bldg.	20263
HOH.	2	post chapel	4420
HOH.	3	heating pl coal	2893
HOH.	3	post office bra	561
HOH.	3	theater w/ dres	8059
HOH.	3	exch main ret s	11097
HOH.	3	cafe, coolg uni	5076
HOH.	3	exch service ou	882
HOH.	5	dep grade schoo	15500
HOH.	9	veh mnt shop. o	9047
HOH.	10	gen purp wareho	24790
HOH.	12	gen purp wareho	14826
HOH.	14	bowling center	3877
HOH.	17	enl barracks w/	7005
HOH.	18	arts and crafts	5552
HOH.	20	sen enl pers qu	7005
HOH.	24	enl pers dining	12166
HOH.	36	fe mnt shop	8860
HOH.	36	lunch room (est	150
HOH.	40	recreation cent	18386
HOH.	41	community bank	6948
HOH.	42	aces facility	6413
HOH.	49	library main	3328
HOH.	50	youth center	4664
HOH.	51	clinic w/beds	22203
HOH.	52	storage shed	2072
HOH.	54	tel exch buildi	4500
HOH.	63	class VI store	1780
HOH.	83	Welcome Center	361
HOH.	88	gymnasium	22200
HOH.	94	child sup sve c	1375
HOH.	95	child sup sve c	2000
HOH.	160	exch serv outle	4664
HOH.	162	enl pers dining	4664
HOH.	169	clothg sales st	3328
HOH.	174	det lavatory bl	2482
HOH.	270	gen instr bldg	4664
HOH.	291	rock crusher pl	681
HOH.	320	HEATING PLANT (	6700
HOH.	322	det lavatory bl	1409
HOH.	323	hutments	3328
HOH.	326	hutments	3328
HOH.	386	gen instr bldg	3328
HOH.	390	veh mnt dir sup	4684
HOH.	391	TANK MAINT.	175
HOH.	392	veh mnt dir sup	17834
HOH.	511	elec mnt shop	16076
HOH.	702	mnt hangar avum	4314
HOH.	703	COMMUNITY AND F	3795
HOH.	708	sewage trm plan	21989
HOH.	739	weather station	641
HOH.	744	ls locker area	3328
HOH.	745	adm & supply bl	3328
HOH.	987	gm mnt bldg	1607
GRAF.	141A	Class VI Store	3018
GRAF.	319A	Facilities Engi	2301
GRAF.	319A1	Facilities Engi	24974
GRAF.	319A2	Facilities Engi	37344
GRAF.	101	DINING FACILITY	9810
GRAF.	105	BANK (AMEXCO, G	7649
GRAF.	107	Library Branch	5348
GRAF.	122	Dependent Nurse	4169
GRAF.	124	Dependent Grade	26586
GRAF.	129	Dispensary With	11195
GRAF.	141	Exchange Main R	13133
GRAF.	142	Post Chapel	4495
GRAF.	148	Exchange Servic	1073
GRAF.	150	Commissary	11668
GRAF.	211	Guest House	8855
GRAF.	219	Bachelor Office	9279
GRAF.	244	Division Breakd	83858
GRAF.	245	General Storeho	28763
GRAF.	248	Sentry Station	67
GRAF.	310	WOOD SHOP	5171
GRAF.	329	Engineer Admini	12735
GRAF.	441	Exchange Automa	1224
GRAF.	445	Open Dining Fac	14223
GRAF.	500	Post Headquarte	20839
GRAF.	503	Operations Buil	2703
GRAF.	508	Youth Center	8274
GRAF.	521	Fire Station	8369
GRAF.	531	Administration	20945
GRAF.	539	Civilian Dormit	20926
GRAF.	547	Gymnasium	36984
GRAF.	602	Tank Repair Sho	11984
GRAF.	607	Exchange Wareho	9361
GRAF.	621	Post Headquarte	37921
GRAF.	622	Exchange Cafete	13710
GRAF.	623	Post Office Bra	2215
GRAF.	623	Clothing Sales	33027
GRAF.	624	Exchange Servic	13091
GRAF.	642	Enlisted Men Ba	70324
GRAF.	651	Guided Missile	7763
GRAF.	655	Guided Missile	1490
GRAF.	1008	CLOTHING SALES	3854
GRAF.	1030	TRAINING AIDS C	10310
GRAF.	2008	TANK TRAINING S	3294
GRAF.	2009	TANK TRAINING S	3294
GRAF.	2025	MAINTENANCE AIR	5570
GRAF.	2026	Aircraft mainte	4809
GRAF.	2031	FLIGHT CONTROL	1664
GRAF.	2039	RADAR BUILDING	528
GRAF.	2220	HUTMENTS	3294
GRAF.	2442	FIXED LAUNDRY	3294

APPFNDIX C:

TYPICAL BUILDING ELECTRICAL CONSUMPTION DATA

P R O F I L E

no.	Name	Subprofiles & Total	WKDAY 100	200	300	400	500	600	700	800	900	1000
1	Administration	LIGHTING WH/HR/SQFT	0.062845	0.057412	0.064093	0.065335	0.065878	0.083636	0.085727	0.176869	0.193304	0.214477
1	Administration	MOTORS WH/HR/SQFT	0.004694	0.004469	0.004654	0.004736	0.005144	0.011263	0.005552	0.009620	0.010797	0.012344
1	Administration	MISSION WH/HR/SQFT	0.022776	0.021573	0.022459	0.022730	0.023877	0.028991	0.034642	0.132821	0.249938	0.269885
1	Administration	SUPPORT WH/HR/SQFT	0.034561	0.039879	0.030622	0.031608	0.032896	0.044868	0.067331	0.125898	0.156929	0.162610
1	Administration	TOTAL WH/HR/SQFT	0.124878	0.123335	0.121829	0.124410	0.127797	0.168760	0.193254	0.445209	0.610969	0.659318
2	Training	LIGHTING WH/HR/SQFT	0.029640	0.029201	0.029338	0.029506	0.029472	0.029999	0.058125	0.327854	0.411548	0.600723
2	Training	MOTORS WH/HR/SQFT	0.000497	0.000490	0.000491	0.000494	0.000493	0.000503	0.001024	0.001399	0.001190	0.001270
2	Training	MISSION WH/HR/SQFT	0.016062	0.015777	0.015325	0.015458	0.015432	0.015848	0.038055	0.127023	0.206380	0.206998
2	Training	SUPPORT WH/HR/SQFT	0.018545	0.019241	0.017688	0.018256	0.018253	0.018804	0.023897	0.054373	0.070992	0.072344
2	Training	TOTAL WH/HR/SQFT	0.064745	0.064791	0.062844	0.063716	0.063652	0.065155	0.121102	0.510650	0.690111	0.881336
3	Motor/Tank Maint/Repair Shop	LIGHTING WH/HR/SQFT	0.093767	0.093485	0.090762	0.085604	0.108107	0.105629	0.136633	0.194355	0.238017	0.286359
3	Motor/Tank Maint/Repair Shop	MOTORS WH/HR/SQFT	0.025170	0.025064	0.024042	0.022105	0.024794	0.023413	0.017041	0.014435	0.023769	0.027806
3	Motor/Tank Maint/Repair Shop	MISSION WH/HR/SQFT	0.103032	0.101385	0.088604	0.081489	0.066234	0.091753	0.075657	0.148947	0.256719	0.247742
3	Motor/Tank Maint/Repair Shop	SUPPORT WH/HR/SQFT	0.025146	0.027234	0.023747	0.023488	0.024019	0.026322	0.027049	0.028155	0.043578	0.052728
3	Motor/Tank Maint/Repair Shop	TOTAL WH/HR/SQFT	0.247117	0.247169	0.227157	0.212687	0.223155	0.247118	0.256381	0.385894	0.562084	0.614637
4	Storage	LIGHTING WH/HR/SQFT	0.043729	0.043996	0.040275	0.037865	0.039651	0.043875	0.045487	0.066906	0.097772	0.107544
4	Storage	MOTORS WH/HR/SQFT	0.071298	0.071313	0.065539	0.061364	0.064384	0.071298	0.073970	0.111337	0.162172	0.177334
4	Storage	MISSION WH/HR/SQFT	0.043729	0.043996	0.040275	0.037865	0.039651	0.043875	0.045487	0.066906	0.097772	0.107544
4	Storage	SUPPORT WH/HR/SQFT	0.068621	0.068660	0.063086	0.059083	0.061983	0.068636	0.071205	0.107023	0.155919	0.170558
4	Storage	TOTAL WH/HR/SQFT	0.227377	0.227967	0.209176	0.196178	0.205671	0.227685	0.236151	0.352173	0.513637	0.562982
5	Medical	LIGHTING WH/HR/SQFT	0.085060	0.083817	0.086819	0.083545	0.086669	0.092392	0.237143	0.226137	0.209584	0.175216
5	Medical	MOTORS WH/HR/SQFT	0.047217	0.046527	0.048193	0.046376	0.048110	0.051287	0.046928	0.047079	0.043633	0.043130
5	Medical	MISSION WH/HR/SQFT	0.223685	0.222027	0.226024	0.221664	0.225825	0.233386	0.226988	0.193126	0.210474	0.201169
5	Medical	SUPPORT WH/HR/SQFT	0.045199	0.044538	0.046133	0.044393	0.046054	0.049094	0.046836	0.147354	0.146682	0.143190
5	Medical	TOTAL WH/HR/SQFT	0.401163	0.396911	0.407169	0.395980	0.406660	0.426160	0.555897	0.613697	0.610374	0.562706
6	Family Housing	LIGHTING WH/HR/SQFT	0.131340	0.104443	0.097099	0.094514	0.084169	0.102547	0.126475	0.167651	0.119048	0.126217
6	Family Housing	MOTORS WH/HR/SQFT	0.075409	0.078790	0.073764	0.071683	0.064046	0.052993	0.059172	0.064024	0.059604	0.061713
6	Family Housing	MISSION WH/HR/SQFT	0.078935	0.053657	0.039733	0.035099	0.064320	0.068758	0.106790	0.095242	0.149712	0.139152
6	Family Housing	SUPPORT WH/HR/SQFT	0	0	0	0	0	0.000962	0.005211	0.101270	0.029548	0.023528
6	Family Housing	TOTAL WH/HR/SQFT	0.285684	0.236890	0.210597	0.201496	0.212535	0.225261	0.297651	0.428189	0.357914	0.350612
7	Troop Housing	LIGHTING WH/HR/SQFT	0.006232	0.005703	0.005559	0.005900	0.010342	0.012180	0.012355	0.010423	0.007632	0.006933
7	Troop Housing	MOTORS WH/HR/SQFT	0.001482	0.001548	0.001450	0.001413	0.001259	0.001041	0.001163	0.001258	0.001171	0.001213
7	Troop Housing	MISSION WH/HR/SQFT	0.001554	0.001057	0.000783	0.000692	0.001267	0.001354	0.002102	0.002024	0.003320	0.003112
7	Troop Housing	SUPPORT WH/HR/SQFT	0.011547	0.009414	0.009162	0.009246	0.012102	0.013392	0.013282	0.012291	0.010495	0.010393
7	Troop Housing	TOTAL WH/HR/SQFT	0.020816	0.017724	0.016355	0.017252	0.024971	0.027969	0.028903	0.025997	0.022619	0.021653
8	Dining/Cafeteria/Snack Bar	LIGHTING WH/HR/SQFT	0.037553	0.037553	0.037553	0.037553	0.037553	0.054580	0.431308	1.381606	1.620893	1.600967
8	Dining/Cafeteria/Snack Bar	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
8	Dining/Cafeteria/Snack Bar	MISSION WH/HR/SQFT	1.712727	1.823526	1.747858	1.740089	1.732650	5.813235	7.854732	6.949876	6.632106	7.124938
8	Dining/Cafeteria/Snack Bar	SUPPORT WH/HR/SQFT	0.000540	0.000540	0.000540	0.000540	0.000547	0.000795	0.000547	0.024017	0.024018	0.024043
8	Dining/Cafeteria/Snack Bar	TOTAL WH/HR/SQFT	1.750821	1.861619	1.785952	1.778182	1.770751	5.868611	8.286589	8.355500	8.277018	8.749848
9	Commissary	LIGHTING WH/HR/SQFT	0.115291	0.102844	0.096248	0.094567	0.097198	0.090672	0.089041	0.194860	0.635143	0.710309
9	Commissary	MOTORS WH/HR/SQFT	5.922587	5.315810	4.588552	4.633328	4.718739	4.559070	4.940689	4.818783	4.665108	5.030264
9	Commissary	MISSION WH/HR/SQFT	0.001876	0.001830	0.002880	0.003929	0.002870	0.003879	0.003861	0.009016	0.017522	0.035574
9	Commissary	SUPPORT WH/HR/SQFT	0.007700	0.016355	0.010806	0.008924	0.013915	0.011815	0.015326	0.027807	0.040587	0.042064
9	Commissary	TOTAL WH/HR/SQFT	6.047455	5.436840	4.698588	4.740749	4.832723	4.665438	5.048917	5.050468	5.358361	5.818292
10	Cold Storage	LIGHTING WH/HR/SQFT	0.035530	0.033159	0.033866	0.030724	0.033693	0.034266	0.037629	0.358580	0.370678	0.387021
10	Cold Storage	MOTORS WH/HR/SQFT	0.607114	0.464948	0.489374	0.438708	0.489768	0.527376	0.469752	0.553106	0.616330	0.654969
10	Cold Storage	MISSION WH/HR/SQFT	0.077594	0.072416	0.073959	0.067098	0.073583	0.074834	0.082178	0.065230	0.078139	0.081584
10	Cold Storage	SUPPORT WH/HR/SQFT	0.008554	0.013397	0.013682	0.048596	0.015446	0.013844	0.061566	0.067378	0.078949	0.039839
10	Cold Storage	TOTAL WH/HR/SQFT	0.728794	0.583920	0.610883	0.585127	0.612492	0.650320	0.651125	1.044296	1.144098	1.163414
11	Heating Plant - Coal/Oil Fired	LIGHTING WH/HR/SQFT	0.204330	0.204720	0.204633	0.204106	0.203968	0.204133	0.198241	0.197576	0.190770	0.188124
11	Heating Plant - Coal/Oil Fired	MOTORS WH/HR/SQFT	4.132927	4.160925	4.125879	4.105912	4.148114	4.186549	4.384197	4.928794	4.924848	4.912842
11	Heating Plant - Coal/Oil Fired	MISSION WH/HR/SQFT	1.097453	1.097453	1.097453	1.097453	1.097453	1.097453	1.228353	1.386513	1.386513	1.386513
11	Heating Plant - Coal/Oil Fired	SUPPORT WH/HR/SQFT	0.034210	0.036091	0.034360	0.033044	0.037692	0.034328	0.038699	0.047994	0.059444	0.062619
11	Heating Plant - Coal/Oil Fired	TOTAL WH/HR/SQFT	5.468921	5.499190	5.462327	5.440517	5.487228	5.522465	5.849491	6.560879	6.561577	6.550100
12	Hutments	LIGHTING WH/HR/SQFT	0.095253	0.095253	0.095253	0.095253	0.095253	0.120810	0.146368	0.125193	0.093616	0.093616
12	Hutments	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
12	Hutments	MISSION WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
12	Hutments	SUPPORT WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
12	Hutments	TOTAL WH/HR/SQFT	0.095253	0.095253	0.095253	0.095253	0.095253	0.120810	0.146368	0.125193	0.093616	0.093616
13	Training Simulator	LIGHTING WH/HR/SQFT	0.038616	0.038616	0.038616	0.038616	0.038616	0.038616	0.038616	0.308928	0.308928	0.308928
13	Training Simulator	MOTORS WH/HR/SQFT	0.018761	0.018761	0.018761	0.018761	0.018761	0.018761	0.018761	0.025015	0.025015	0.025015
13	Training Simulator	MISSION WH/HR/SQFT	0.566900	0.537755	0.570144	0.503905	0.562554	0.560733	0.511098	2.935716	2.460759	2.538956
13	Training Simulator	SUPPORT WH/HR/SQFT	0.012422	0.012422	0.008281	0.012422	0.008281	0.008281	0.012422	0.025898	0.039375	0.039375
13	Training Simulator	TOTAL WH/HR/SQFT	0.636701	0.607555	0.635804	0.573705	0.628214	0.626392	0.580898	3.295559	2.834078	2.912275
14	Missile Equip Maint Shop	LIGHTING WH/HR/SQFT	0.325487	0.324444	0.326220	0.325467	0.325507	0.325807	0.315117	0.251928	0.248747	0.249744
14	Missile Equip Maint Shop	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
14	Missile Equip Maint Shop	MISSION WH/HR/SQFT	0.241532	0.240614	0.241053	0.253546	0.244781	0.248210	0.298402	0.360931	0.380332	0.491964
14	Missile Equip Maint Shop	SUPPORT WH/HR/SQFT	0.127325	0.127059	0.127513	0.127320	0.127331	0.127428	0.146788	0.234765	0.243508	0.247732
14	Missile Equip Maint Shop	TOTAL WH/HR/SQFT	0.694346	0.692119	0.695587	0.706334	0.697620	0.701526	0.760308	0.847625	0.872588	0.989010
15	Electronics/Electr Maint Shop	LIGHTING WH/HR/SQFT	0.036131	0.036131	0.036131	0.036131	0.036131	0.036131	0.036131	0.376900	0.532499	0.532499
15	Electronics/Electr Maint Shop	MOTORS WH/HR/SQFT	0.410162	0.248340	0.410162	0.410162	0.248340	0.248340	0.410162	0.608667	0.610110	0.414214
15	Electronics/Electr Maint Shop	MISSION WH/HR/SQFT	0.159240	0.159240	0.159240	0.159240	0.159240	0.159240	0.159240	0.256892	0.361080	0.366588
15	Electronics/Electr Maint Shop	SUPPORT WH/HR/SQFT	0.021019	0.021019	0.021019	0.021019	0.021019	0.021019	0.021019	0.085106	0.085607	0.085607
15	Electronics/Electr Maint Shop	TOTAL WH/HR/SQFT	0.626554	0.464731	0.626554	0.626554	0.464731	0.464731	0.626554	1.327566	1.589298	1.398910
16.2	Dining (Troops)	LIGHTING WH/HR/SQFT	0.039415	0.039412	0.039425	0.039044	0.061795	0.129162	0.149436	0.149960	0.132522	0.129083
16.2	Dining (Troops)	MOTORS WH/HR/SQFT	0.000687	0.000687	0.000687	0.000687	0.000808	0.000872	0.000976	0.000976	0.000936	0.000842
16.2	Dining (Troops)	MISSION WH/HR/SQFT	0.392231	0.371732	0.364196	0.513069	0.976732	1.060919	1.484897	1.523601	1.343937	1.337060
16.2	Dining (Troops)	SUPPORT WH/HR/SQFT	0.000049	0.000049	0.000049	0.000047	0.001206	0.001515	0.001510	0.003049	0.006589	0.006620
16.2	Dining (Troops)	TOTAL WH/HR/SQFT	0.432384	0.411881	0.404359	0.553649	1.040543	1.192470	1.636820	1.677595	1.483985	1.475307
17	School	LIGHTING WH/HR/SQFT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.362195	[illegible]	[illegible]
17	School	MOTORS WH/HR/SQFT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.001616	[illegible]
17	School	MISSION WH/HR/SQFT	[illegible]	[illegible]	[illegible]	0.002157	[illegible]	0.002277	0.001785	0.017539	0.047234	[illegible]
17	School	SUPPORT WH/HR/SQFT	[illegible]	0.052471	0.050400	0.049744	0.055249	0.040519	0.048104	0.132051	0.129450	0.206163
17	School	TOTAL WH/HR/SQFT	[illegible]	0.077034	0.075162	0.074548	[illegible]	0.077970	0.230039	0.513556	0.623956	0.701751
18	Telephone Exchange	LIGHTING WH/HR/SQFT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.501340	[illegible]
18	Telephone Exchange	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
18	Telephone Exchange	MISSION WH/HR/SQFT	[illegible]	1.428447	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.128651	3.078117	[illegible]
18	Telephone Exchange	SUPPORT WH/HR/SQFT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

P R O F I L E

no.	Name	Subprofiles & Total	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000
1	Administration	LIGHTING WH/HR/SQFT	0.217230	0.228839	0.198429	0.219242	0.193356	0.211919	0.105939	0.107859	0.073982	0.062558
1	Administration	MOTORS WH/HR/SQFT	0.012221	0.013681	0.012732	0.013375	0.010277	0.012198	0.009237	0.008273	0.005697	0.006951
1	Administration	MISSION WH/HR/SQFT	0.258719	0.241735	0.220255	0.261557	0.231212	0.247845	0.204684	0.048639	0.027899	0.026048
1	Administration	SUPPORT WH/HR/SQFT	0.130997	0.127888	0.125297	0.130386	0.128485	0.134756	0.101414	0.094107	0.079816	0.058555
1	Administration	TOTAL WH/HR/SQFT	0.619168	0.612144	0.550715	0.624562	0.563332	0.606721	0.421276	0.258879	0.187396	0.154113
2	Training	LIGHTING WH/HR/SQFT	0.592241	0.541612	0.555024	0.625795	0.625691	0.625562	0.315846	0.162344	0.173890	0.170869
2	Training	MOTORS WH/HR/SQFT	0.002779	0.002586	0.002579	0.003080	0.002994	0.002887	0.002226	0.000742	0.000956	0.000900
2	Training	MISSION WH/HR/SQFT	0.380483	0.333839	0.350402	0.439305	0.410330	0.388332	0.290085	0.050372	0.045815	0.034653
2	Training	SUPPORT WH/HR/SQFT	0.054241	0.116284	0.089248	0.076362	0.074922	0.094775	0.068562	0.030448	0.031448	0.027247
2	Training	TOTAL WH/HR/SQFT	1.029745	0.994321	0.997055	1.144543	1.113938	1.111557	0.676720	0.243907	0.252109	0.233669
3	Motor/Tank Maint/Repair Shop	LIGHTING WH/HR/SQFT	0.322673	0.335455	0.344283	0.364357	0.370904	0.380801	0.347394	0.205075	0.184976	0.185409
3	Motor/Tank Maint/Repair Shop	MOTORS WH/HR/SQFT	0.045193	0.085651	0.082796	0.080187	0.080719	0.087739	0.074063	0.029679	0.013746	0.020327
3	Motor/Tank Maint/Repair Shop	MISSION WH/HR/SQFT	0.221979	0.272205	0.272432	0.306261	0.307520	0.295344	0.204843	0.161372	0.118001	0.109265
3	Motor/Tank Maint/Repair Shop	SUPPORT WH/HR/SQFT	0.043509	0.059976	0.060039	0.057664	0.051579	0.053844	0.047682	0.040155	0.032309	0.026831
3	Motor/Tank Maint/Repair Shop	TOTAL WH/HR/SQFT	0.633356	0.753289	0.759551	0.808469	0.810723	0.817729	0.673983	0.436283	0.349033	0.341833
4	Storage	LIGHTING WH/HR/SQFT	0.109475	0.131227	0.132264	0.140007	0.139622	0.141055	0.116669	0.076676	0.061365	0.059501
4	Storage	MOTORS WH/HR/SQFT	0.182735	0.217338	0.219144	0.233258	0.233908	0.235930	0.194456	0.125876	0.100702	0.098625
4	Storage	MISSION WH/HR/SQFT	0.109475	0.131227	0.132264	0.140007	0.139622	0.141055	0.116669	0.076676	0.061365	0.059501
4	Storage	SUPPORT WH/HR/SQFT	0.175622	0.208977	0.210709	0.224205	0.224754	0.226719	0.186904	0.121099	0.096883	0.094827
4	Storage	TOTAL WH/HR/SQFT	0.577308	0.688772	0.694383	0.737479	0.737908	0.744759	0.614700	0.400328	0.320316	0.312456
5	Medical	LIGHTING WH/HR/SQFT	0.118199	0.077100	0.123120	0.120536	0.104777	0.088704	0.077434	0.088485	0.095653	0.086967
5	Medical	MOTORS WH/HR/SQFT	0.045801	0.041906	0.047707	0.046706	0.040600	0.034371	0.042984	0.049119	0.053097	0.048276
5	Medical	MISSION WH/HR/SQFT	0.212478	0.185651	0.216250	0.217265	0.189113	0.149063	0.186593	0.201996	0.257850	0.349214
5	Medical	SUPPORT WH/HR/SQFT	0.155376	0.143435	0.159578	0.155945	0.129779	0.107666	0.055240	0.053407	0.050827	0.046212
5	Medical	TOTAL WH/HR/SQFT	0.531855	0.448093	0.546657	0.540455	0.464270	0.379805	0.362253	0.393009	0.457428	0.530671
6	Family Housing	LIGHTING WH/HR/SQFT	0.102280	0.083225	0.101006	0.127564	0.126475	0.193521	0.163693	0.202592	0.338765	0.346947
6	Family Housing	MOTORS WH/HR/SQFT	0.059525	0.056364	0.059574	0.063233	0.063198	0.072034	0.068400	0.069812	0.067100	0.065595
6	Family Housing	MISSION WH/HR/SQFT	0.119422	0.102232	0.117818	0.124291	0.123301	0.130791	0.274744	0.274918	0.244044	0.204002
6	Family Housing	SUPPORT WH/HR/SQFT	0.014670	0.004667	0.010268	0.013440	0.024267	0.050446	0.064530	0.151466	0.106352	0.088902
6	Family Housing	TOTAL WH/HR/SQFT	0.295898	0.246489	0.288667	0.328528	0.337242	0.446793	0.571369	0.698789	0.756263	0.705447
7	Troop Housing	LIGHTING WH/HR/SQFT	0.006463	0.006088	0.006438	0.006960	0.006939	0.008257	0.007380	0.010642	0.016096	0.018222
7	Troop Housing	MOTORS WH/HR/SQFT	0.001170	0.001108	0.001171	0.001243	0.001242	0.001416	0.001344	0.001372	0.001319	0.001289
7	Troop Housing	MISSION WH/HR/SQFT	0.002906	0.002428	0.002875	0.002812	0.002796	0.002943	0.005538	0.005438	0.004800	0.004013
7	Troop Housing	SUPPORT WH/HR/SQFT	0.011189	0.012948	0.010521	0.010107	0.010813	0.011683	0.018376	0.023052	0.020177	0.020241
7	Troop Housing	TOTAL WH/HR/SQFT	0.021729	0.022574	0.021006	0.021122	0.021791	0.024300	0.032639	0.040506	0.042393	0.043766
8	Dining/Cafeteria/Snack Bar	LIGHTING WH/HR/SQFT	1.592153	1.626065	1.616909	1.601726	1.593863	1.604314	1.614216	1.605589	1.605252	1.597749
8	Dining/Cafeteria/Snack Bar	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
8	Dining/Cafeteria/Snack Bar	MISSION WH/HR/SQFT	5.961501	7.360121	8.209397	7.944045	6.175653	6.485987	5.152224	5.574316	5.057426	5.181401
8	Dining/Cafeteria/Snack Bar	SUPPORT WH/HR/SQFT	0.036051	0.048292	0.036122	0.023784	0.023882	0.036217	0.039905	0.035855	0.037260	0.037329
8	Dining/Cafeteria/Snack Bar	TOTAL WH/HR/SQFT	7.589706	9.034479	9.862429	9.569556	7.793400	8.126519	6.806346	7.215760	6.699939	6.816480
9	Commissary	LIGHTING WH/HR/SQFT	0.694249	0.727407	0.785225	0.822348	0.837367	0.822546	0.822171	0.862711	0.431369	0.122073
9	Commissary	MOTORS WH/HR/SQFT	5.097529	5.219261	5.671775	5.906169	5.771529	5.692428	5.750930	5.974950	6.454606	6.397389
9	Commissary	MISSION WH/HR/SQFT	0.089227	0.088448	0.089401	0.089476	0.089917	0.088356	0.087684	0.087162	0.056564	0.007097
9	Commissary	SUPPORT WH/HR/SQFT	0.058683	0.058177	0.066841	0.060342	0.060861	0.062194	0.056903	0.067602	0.071129	0.032454
9	Commissary	TOTAL WH/HR/SQFT	5.939689	6.093295	6.613244	6.870337	6.759675	6.665525	6.717690	6.992427	7.013670	6.559015
10	Cold Storage	LIGHTING WH/HR/SQFT	0.384928	0.352575	0.329527	0.348817	0.352440	0.295645	0.029132	0.029593	0.034407	0.033659
10	Cold Storage	MOTORS WH/HR/SQFT	0.632386	0.534886	0.453966	0.527408	0.539178	0.430598	0.388598	0.452931	0.544208	0.515163
10	Cold Storage	MISSION WH/HR/SQFT	0.079696	0.072674	0.068225	0.073339	0.074197	0.062240	0.137115	0.096198	0.075141	0.073508
10	Cold Storage	SUPPORT WH/HR/SQFT	0.035014	0.070075	0.071042	0.072597	0.071638	0.059427	0.056841	0.060329	0.025135	0.022757
10	Cold Storage	TOTAL WH/HR/SQFT	1.132025	1.030211	0.922763	1.022162	1.037455	0.847912	0.611688	0.639053	0.678893	0.645089
11	Heating Plant - Coal/Oil Fired	LIGHTING WH/HR/SQFT	0.188494	0.188726	0.186803	0.188188	0.189682	0.190665	0.195975	0.204494	0.205135	0.205256
11	Heating Plant - Coal/Oil Fired	MOTORS WH/HR/SQFT	4.777798	4.880251	4.738357	4.787998	4.789045	4.922623	4.484465	4.298574	4.159404	4.211512
11	Heating Plant - Coal/Oil Fired	MISSION WH/HR/SQFT	1.386513	1.386513	1.386513	1.386513	1.386513	1.386513	1.240927	1.097453	1.097453	1.097453
11	Heating Plant - Coal/Oil Fired	SUPPORT WH/HR/SQFT	0.071322	0.069792	0.080686	0.082962	0.071086	0.071798	0.067417	0.051852	0.045986	0.045964
11	Heating Plant - Coal/Oil Fired	TOTAL WH/HR/SQFT	6.424129	6.525284	6.392362	6.445664	6.436326	6.571600	5.988785	5.652374	5.507980	5.560186
12	Hutments	LIGHTING WH/HR/SQFT	0.093616	0.093616	0.093616	0.093616	0.093616	0.093616	0.114791	0.146368	0.146368	0.152387
12	Hutments	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
12	Hutments	MISSION WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
12	Hutments	SUPPORT WH/HR/SQFT	0	0	0	0.034397	0.034397	0	0	0	0	0
12	Hutments	TOTAL WH/HR/SQFT	0.093616	0.093616	0.093616	0.128013	0.128013	0.093616	0.114791	0.146368	0.146368	0.152387
13	Training Simulator	LIGHTING WH/HR/SQFT	0.308928	0.308928	0.308928	0.308928	0.308928	0.308928	0.115846	0.038616	0.038616	0.038616
13	Training Simulator	MOTORS WH/HR/SQFT	0.025015	0.025015	0.025015	0.025015	0.025015	0.025015	0.018761	0.018761	0.018761	0.018761
13	Training Simulator	MISSION WH/HR/SQFT	2.380045	2.244815	2.184532	2.345897	2.108454	2.230327	1.462780	0.615197	0.534812	0.591340
13	Training Simulator	SUPPORT WH/HR/SQFT	0.035640	0.027765	0.027359	0.031093	0.031093	0.031500	0.023625	0.016563	0.016563	0.012422
13	Training Simulator	TOTAL WH/HR/SQFT	2.749631	2.606525	2.545835	2.710934	2.473491	2.595771	1.621015	0.689138	0.608754	0.661141
14	Missile Equip Maint Shop	LIGHTING WH/HR/SQFT	0.249070	0.249016	0.249006	0.249370	0.248714	0.248563	0.294318	0.398076	0.405134	0.367914
14	Missile Equip Maint Shop	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
14	Missile Equip Maint Shop	MISSION WH/HR/SQFT	0.420378	0.332018	0.280497	0.470768	0.707081	0.328232	0.373615	0.254297	0.248237	0.270847
14	Missile Equip Maint Shop	SUPPORT WH/HR/SQFT	0.246004	0.243594	0.241531	0.244339	0.239278	0.238107	0.148283	0.126541	0.126408	0.126777
14	Missile Equip Maint Shop	TOTAL WH/HR/SQFT	0.915453	0.824629	0.771035	0.964477	1.195075	0.814902	0.816217	0.778915	0.779781	0.765538
15	Electronics/Electr Maint Shop	LIGHTING WH/HR/SQFT	0.532499	0.532499	0.532499	0.532499	0.532499	0.532499	0.531705	0.036131	0.036131	0.036131
15	Electronics/Electr Maint Shop	MOTORS WH/HR/SQFT	0.610110	0.633219	0.610110	0.633219	0.633219	0.610110	0.607864	0.508117	0.410162	0.410162
15	Electronics/Electr Maint Shop	MISSION WH/HR/SQFT	0.354215	0.346134	0.354215	0.366648	0.366598	0.366598	0.334118	0.249757	0.159240	0.159240
15	Electronics/Electr Maint Shop	SUPPORT WH/HR/SQFT	0.085607	0.085607	0.085607	0.035607	0.085607	0.077542	0.053374	0.021773	0.021019	0.021019
15	Electronics/Electr Maint Shop	TOTAL WH/HR/SQFT	1.582432	1.597460	1.582432	1.617975	1.617925	1.586750	1.527063	0.815780	0.626554	0.626554
16.2	Dining (Troops)	LIGHTING WH/HR/SQFT	0.135198	0.192295	0.205674	0.170269	0.132671	0.121798	0.170705	0.221632	0.172720	0.138875
16.2	Dining (Troops)	MOTORS WH/HR/SQFT	0.000842	0.000926	0.001042	0.000926	0.000842	0.000842	0.000976	0.001054	0.000976	0.000775
16.2	Dining (Troops)	MISSION WH/HR/SQFT	1.354931	1.344534	1.447475	1.188239	0.992661	1.241281	1.346377	1.385117	0.969925	0.653556
16.2	Dining (Troops)	SUPPORT WH/HR/SQFT	0.009266	0.014573	0.014607	0.014647	0.014623	0.014689	0.015279	0.011807	0.012226	0.011309
16.2	Dining (Troops)	TOTAL WH/HR/SQFT	1.500239	1.552329	1.668799	1.374082	1.140798	1.378811	1.533340	1.619612	1.155848	0.804516
17	School	LIGHTING WH/HR/SQFT	0.452131	0.445364	0.435906	0.402196	0.442743	0.438879	0.390472	0.310335	0.111521	0.020392
17	School	MOTORS WH/HR/SQFT	0.001616	0.001616	0.001616	0.001616	0.001616	0.001616	0.001616	0.001616	0.000969	0.000969
17	School	MISSION WH/HR/SQFT	0.038685	0.029424	0.029415	0.042848	0.047034	0.042408	0.018981	0.012295	0.002430	0.002390
17	School	SUPPORT WH/HR/SQFT	0.201028	0.191900	0.169431	0.122557	0.102327	0.127564	0.163041	0.140975	0.063956	0.057040
17	School	TOTAL WH/HR/SQFT	0.693461	0.668306	0.636370	0.569219	0.593722	0.610468	0.574111	0.465223	0.178878	0.080793
18	Telephone Exchange	LIGHTING WH/HR/SQFT	0.501340	0.501340	0.501340	0.501340	0.501340	0.501340	0.419297	0.425832	0.441883	0.441883
18	Telephone Exchange	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
18	Telephone Exchange	MISSION WH/HR/SQFT	3.069671	3.054606	3.057174	3.071544	3.065200	2.216791	1.645591	1.601718	1.600740	1.600740
18	Telephone Exchange	SUPPORT WH/HR/SQFT	0.098109	0.295346	0.104814	0.093349	0.086977	0.087699	0.258802	0.270955	0.080101	0.076051

Bldg	Name	Output (Wh/Sf) Total	2100	2200	2300	2400	SUM (WH/SF/DY)	WKEND 100	200	300	400	500
1	Administration	LIGHTING WH/HR/SQFT	0.063011	0.059517	0.057[illegible]	0.05[illegible]400	2.92[illegible]	0.0[illegible]710	0.0585[illegible]	0.059015	0.061312	0.06[illegible]543
1	Administration	MOTORS WH/HR/SQFT	0.005[illegible]	0.005327	0.004[illegible]	0.004[illegible]	0.1987[illegible]	0.005299	0.005[illegible]30	0.005191	0.005435	0.005463
1	Administration	MISSION WH/HR/SQFT	0.025264	0.020802	0.02[illegible]	0.02[illegible]244	2.6923[illegible]	0.027139	0.027014	0.026750	0.027486	0.027454
1	Administration	SUPPORT WH/HR/SQFT	0.046[illegible]	0.046381	0.04[illegible]	0.044004	2.0234256	0.036727	0.03[illegible]293	0.033031	0.031007	0.031[illegible]
1	Administration	TOTAL WH/HR/SQFT	0.140425	0.135030	0.13[illegible]	0.1[illegible]	7.8403023	0.125677	0.1240[illegible]	0.123989	0.125242	0.124579
2	Training	LIGHTING WH/HR/SQFT	0.034[illegible]	0.02[illegible]744	0.029020	0.029[illegible]	5.[illegible]	0.030[illegible]24	0.029618	0.02[illegible]971	0.029853	0.0[illegible]12
2	Training	MOTORS WH/HR/SQFT	0.000[illegible]	0.000498	0.000[illegible]05	0.000[illegible]	0.031[illegible]	0.000514	0.000500	0.000507	0.000505	0.000506
2	Training	MISSION WH/HR/SQFT	0.021849	0.018125	0.016[illegible]	0.01[illegible]	3.4[illegible]	0.018025	0.0175[illegible]	0.017[illegible]	0.017600	0.017[illegible]53
2	Training	SUPPORT WH/HR/SQFT	0.021766	0.019952	0.020[illegible]	0.01[illegible]	1.0[illegible]21	0.017694	0.0176[illegible]	0.018725	0.017658	0.017662
2	Training	TOTAL WH/HR/SQFT	0.078646	0.060912	0.06[illegible]	0.065[illegible]	10.6[illegible]	0.065558	0.065146	0.066[illegible]11	0.065617	0.065734
3	Motor/Tank Maint/Repair Shop	LIGHTING WH/HR/SQFT	0.199028	0.197756	0.15[illegible]	0.1[illegible]	5.1521[illegible]	0.109[illegible]	0.110085	0.113[illegible]	0.110336	0.109658
3	Motor/Tank Maint/Repair Shop	MOTORS WH/HR/SQFT	0.011[illegible]	0.021643	0.01[illegible]151	0.0186[illegible]	0.8985[illegible]	0.021698	0.0217[illegible]	0.015437	0.021796	0.021620
3	Motor/Tank Maint/Repair Shop	MISSION WH/HR/SQFT	0.106074	0.095111	0.0[illegible]	0.0[illegible]	3.[illegible]168	0.048304	0.0480[illegible]	0.049[illegible]32	0.048458	0.048190
3	Motor/Tank Maint/Repair Shop	SUPPORT WH/HR/SQFT	0.023762	0.031008	0.02[illegible]	0.02[illegible]	0.8843[illegible]	0.018301	0.015142	0.014694	0.013842	0.015630
3	Motor/Tank Maint/Repair Shop	TOTAL WH/HR/SQFT	0.340288	0.345519	0.288[illegible]	0.25[illegible]	10.83[illegible]	0.198267	0.195318	0.193767	0.194433	0.195100
4	Storage	LIGHTING WH/HR/SQFT	0.058866	0.060626	0.050940	0.045452	1.8908655	0.034893	0.034015	0.033704	0.033708	0.034040
4	Storage	MOTORS WH/HR/SQFT	0.098179	0.099688	0.083254	0.074114	3.1272269	0.057272	0.056420	0.055972	0.056165	0.056357
4	Storage	MISSION WH/HR/SQFT	0.058866	0.060626	0.050940	0.045452	1.8908655	0.034893	0.034015	0.033704	0.033708	0.034040
4	Storage	SUPPORT WH/HR/SQFT	0.094362	0.095896	0.080117	0.071331	3.0071918	0.055099	0.054245	0.053810	0.053984	0.054190
4	Storage	TOTAL WH/HR/SQFT	0.310276	0.316837	0.265269	0.2[illegible]351	9.9161497	0.182160	0.1786[illegible]	0.177193	0.177567	0.178629
5	Medical	LIGHTING WH/HR/SQFT	0.085936	0.087120	0.090024	0.083454	2.6899530	0.060288	0.0556[illegible]	0.054442	0.053080	0.052808
5	Medical	MOTORS WH/HR/SQFT	0.047709	0.048360	0.050000	0.046326	1.1134492	0.046127	0.042614	0.041655	0.040612	0.040404
5	Medical	MISSION WH/HR/SQFT	0.373426	0.349825	0.262264	0.251107	5.5664754	0.183894	0.17740[illegible]	0.173410	0.169070	0.168202
5	Medical	SUPPORT WH/HR/SQFT	0.045664	0.046293	0.047663	0.044345	2.0011139	0.031649	0.02927[illegible]	0.028581	0.027865	0.027722
5	Medical	TOTAL WH/HR/SQFT	0.552731	0.531599	0.450203	0.425234	11.390991	0.321960	0.304952	0.298089	0.290630	0.289138
6	Family Housing	LIGHTING WH/HR/SQFT	0.301[illegible]36	0.346304	0.224841	0.17[illegible]03	4.0211710	0.12[illegible]31	0.0[illegible]	0.042242	0.023551	0.023409
6	Family Housing	MOTORS WH/HR/SQFT	0.064240	0.066334	0.068399	0.065070	1.5662871	0.076929	0.065752	0.049517	0.052328	0.052020
6	Family Housing	MISSION WH/HR/SQFT	0.226867	0.153097	0.042516	0.05[illegible]16	3.0230712	0.200232	0.197393	0.144466	0.131922	0.136698
6	Family Housing	SUPPORT WH/HR/SQFT	0.098867	0.159684	0.153602	0.083407	1.185096[illegible]	0	0	0	0	0
6	Family Housing	TOTAL WH/HR/SQFT	0.721712	0.725420	0.469360	0.378006	9.7976257	0.400842	0.342[illegible]1	0.2362[illegible]	0.207802	0.212128
7	Troop Housing	LIGHTING WH/HR/SQFT	0.017923	0.015087	0.011554	0.008324	0.23044[illegible]	0.006901	0.005171	0.003884	0.003575	0.003573
7	Troop Housing	MOTORS WH/HR/SQFT	0.001262	0.001304	0.001344	0.001239	0.0308301	0.001291	0.001102	0.000830	0.000877	0.000872
7	Troop Housing	MISSION WH/HR/SQFT	0.004462	0.003012	0.000838	0.001056	0.0631940	0.003360	0.003313	0.002425	0.002215	0.002295
7	Troop Housing	SUPPORT WH/HR/SQFT	0.017687	0.016735	0.015498	0.013352	0.3243158	0.008273	0.007246	0.006650	0.006650	0.007134
7	Troop Housing	TOTAL WH/HR/SQFT	0.041336	0.036939	0.029236	0.024[illegible]74	0.6487854	0.019827	0.016833	0.013795	0.013319	0.013874
8	Dining/Cafeteria/Snack Bar	LIGHTING WH/HR/SQFT	1.591119	0.781784	0.07755[illegible]	0.037552	24.782[illegible]	0.018553	0.018553	0.018553	0.018553	0.018553
8	Dining/Cafeteria/Snack Bar	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
8	Dining/Cafeteria/Snack Bar	MISSION WH/HR/SQFT	3.748260	1.863329	1.805960	1.801231	115.45250	1.686360	1.757569	1.779822	1.723745	1.729976
8	Dining/Cafeteria/Snack Bar	SUPPORT WH/HR/SQFT	0.024894	0.000541	0.000540	0.000540	0.4573509	0.000534	0.000534	0.000534	0.000534	0.000534
8	Dining/Cafeteria/Snack Bar	TOTAL WH/HR/SQFT	5.364275	2.645655	1.884054	1.839124	139.69282	1.705448	1.776656	1.798909	1.742832	1.749063
9	Commissary	LIGHTING WH/HR/SQFT	0.122597	0.113627	0.114502	0.113120	9.6126754	0.086671	0.090333	0.071153	0.085554	0.073796
9	Commissary	MOTORS WH/HR/SQFT	6.073488	5.602429	5.567024	5.667625	130.12017	5.611005	5.230529	4.528814	4.654625	4.682658
9	Commissary	MISSION WH/HR/SQFT	0.007098	0.006566	0.007105	0.003449	0.8808009	0.002546	0.004691	0.003866	0.003414	0.004510
9	Commissary	SUPPORT WH/HR/SQFT	0.026228	0.038747	0.034018	0.034533	0.9260237	0.027556	0.017911	0.008175	0.011671	0.014773
9	Commissary	TOTAL WH/HR/SQFT	6.231412	5.841370	5.722650	5.819026	141.54487	5.727700	5.343465	4.612009	4.755266	4.775738
10	Cold Storage	LIGHTING WH/HR/SQFT	0.032545	0.030587	0.032417	0.033801	3.6752282	0.036586	0.033581	0.034267	0.032093	0.033977
10	Cold Storage	MOTORS WH/HR/SQFT	0.470288	0.444612	0.468445	0.514444	12.228569	0.625294	0.470872	0.495174	0.458263	0.493866
10	Cold Storage	MISSION WH/HR/SQFT	0.071075	0.066799	0.070797	0.073817	1.8414475	0.051389	0.047168	0.048131	0.045078	0.047723
10	Cold Storage	SUPPORT WH/HR/SQFT	0.018462	0.060031	0.021918	0.021013	1.0275413	0.020754	0.015395	0.011980	0.052509	0.015576
10	Cold Storage	TOTAL WH/HR/SQFT	0.592371	0.602029	0.593578	0.643077	18.772786	0.734025	0.567018	0.589554	0.587944	0.591164
11	Heating Plant - Coal/Oil Fired	LIGHTING WH/HR/SQFT	0.205231	0.204937	0.204463	0.204157	4.7628213	0.193796	0.193117	0.192994	0.193946	0.194229
11	Heating Plant - Coal/Oil Fired	MOTORS WH/HR/SQFT	4.152578	4.188151	4.203474	4.123029	106.72625	3.925490	3.910055	3.926384	3.937942	3.981769
11	Heating Plant - Coal/Oil Fired	MISSION WH/HR/SQFT	1.097453	1.097453	1.097453	1.097453	29.214798	1.034584	1.034584	1.034584	1.034584	1.034584
11	Heating Plant - Coal/Oil Fired	SUPPORT WH/HR/SQFT	0.045266	0.043718	0.047546	0.045511	1.2594028	0.043344	0.037327	0.033568	0.033606	0.035838
11	Heating Plant - Coal/Oil Fired	TOTAL WH/HR/SQFT	5.500529	5.534260	5.552939	5.470151	141.96527	5.197216	5.175084	5.187532	5.200079	5.246362
12	Hutments	LIGHTING WH/HR/SQFT	0.158407	0.126830	0.095253	0.095253	2.6532294	0.084337	0.084337	0.084337	0.084337	0.084337
12	Hutments	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
12	Hutments	MISSION WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
12	Hutments	SUPPORT WH/HR/SQFT	0	0	0	0	0.0687949	0	0	0	0	0
12	Hutments	TOTAL WH/HR/SQFT	0.158407	0.126830	0.095253	0.095253	2.7220243	0.084337	0.084337	0.084337	0.084337	0.084337
13	Training Simulator	LIGHTING WH/HR/SQFT	0.038616	0.038616	0.038616	0.038616	3.4368324	0.038616	0.038616	0.038616	0.038616	0.038616
13	Training Simulator	MOTORS WH/HR/SQFT	0.018761	0.018761	0.018761	0.018761	0.5065630	0.018761	0.018761	0.018761	0.018761	0.018761
13	Training Simulator	MISSION WH/HR/SQFT	0.590278	0.572118	0.577982	0.577982	30.765089	0.514350	0.542086	0.590047	0.498047	0.571067
13	Training Simulator	SUPPORT WH/HR/SQFT	0.012422	0.008281	0.012422	0.008281	0.4742220	0.012422	0.008281	0.004140	0.008281	0.004140
13	Training Simulator	TOTAL WH/HR/SQFT	0.660078	0.637777	0.647782	0.643641	35.182706	0.584159	0.607745	0.651565	0.563707	0.632506
14	Missile Equip Maint Shop	LIGHTING WH/HR/SQFT	0.343709	0.444244	0.325049	0.323804	7.3140979	0.323240	0.323354	0.323505	0.323655	0.323392
14	Missile Equip Maint Shop	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
14	Missile Equip Maint Shop	MISSION WH/HR/SQFT	0.270598	0.294759	0.284606	0.255239	7.7933687	0.222615	0.226672	0.234177	0.208499	0.201356
14	Missile Equip Maint Shop	SUPPORT WH/HR/SQFT	0.127042	0.127179	0.127214	0.126895	4.1259730	0.126751	0.126781	0.126819	0.126857	0.126790
14	Missile Equip Maint Shop	TOTAL WH/HR/SQFT	0.741350	0.766184	0.736870	0.705939	19.233439	0.672608	0.678808	0.684502	0.659012	0.651539
15	Electronics/Electr Maint Shop	LIGHTING WH/HR/SQFT	0.036131	0.036131	0.036131	0.036131	5.6744471	0.036131	0.036131	0.036131	0.036131	0.036131
15	Electronics/Electr Maint Shop	MOTORS WH/HR/SQFT	0.214138	0.410162	0.214138	0.410162	10.933563	0.410162	0.410162	0.410162	0.410162	0.410162
15	Electronics/Electr Maint Shop	MISSION WH/HR/SQFT	0.159240	0.159240	0.159240	0.159240	5.7929740	0.159240	0.159240	0.159240	0.159240	0.159240
15	Electronics/Electr Maint Shop	SUPPORT WH/HR/SQFT	0.021019	0.021019	0.021019	0.021019	1.1103067	0.021019	0.021019	0.021019	0.021019	0.021019
15	Electronics/Electr Maint Shop	TOTAL WH/HR/SQFT	0.430530	0.626554	0.430530	0.626554	23.511291	0.626554	0.626554	0.626554	0.626554	0.626554
16	Dining (Troops)	LIGHTING WH/HR/SQFT	0.130912	0.128[illegible]36	0.063814	0.043470	2.9470427	0.043038	0.046482	0.051674	0.046409	0.046251
16	Dining (Troops)	MOTORS WH/HR/SQFT	0.000687	0.000687	0.000687	0.000687	0.0201217	0.000733	0.000733	0.000733	0.000733	0.000733
16	Dining (Troops)	MISSION WH/HR/SQFT	0.653262	0.615861	0.531060	0.444353	23.538719	0.511621	0.467738	0.398368	0.388541	0.389612
16	Dining (Troops)	SUPPORT WH/HR/SQFT	0.009412	0.005411	0.002730	0.000049	0.1715400	0.000049	0.000049	0.000049	0.000049	0.000049
16	Dining (Troops)	TOTAL WH/HR/SQFT	0.802295	0.750096	0.598293	0.488561	26.677424	0.556242	0.515009	0.450825	0.435734	0.436646
17	School	LIGHTING WH/HR/SQFT	0.020416	0.020613	0.020328	0.020532	5.0450808	0.019007	0.020278	0.021100	0.020613	0.020[illegible]
17	School	MOTORS WH/HR/SQFT	0.000969	0.000969	0.000969	0.000969	0.0242429	0.000646	0.000646	0.000646	0.000646	0.000646
17	School	MISSION WH/HR/SQFT	0.002392	0.002457	0.002216	0.002005	0.4070670	0.000949	0.000979	0.001046	0.001006	0.000988
17	School	SUPPORT WH/HR/SQFT	0.054657	0.059252	0.056947	0.056604	2.4404051	0.056584	0.052444	0.050560	0.051155	0.053259
17	School	TOTAL WH/HR/SQFT	0.078441	0.083293	0.080512	0.080272	7.9229297	0.070008	0.074340	0.073354	0.073422	0.075292
18	Telephone Exchange	LIGHTING WH/HR/SQFT	0.441084	0.441084	0.441084	0.441084	11.100212	0.393466	0.393466	0.393466	0.393466	0.393466
18	Telephone Exchange	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
18	Telephone Exchange	MISSION WH/HR/SQFT	1.600240	1.600240	1.600240	1.600240	49.309347	1.478447	1.478447	1.478447	1.478447	1.478447
18	Telephone Exchange	SUPPORT WH/HR/SQFT	0.067944	0.080101	0.076051	0.072000	2.5102706	0.065864	0.056719	0.047575	0.051626	0.051626

[illegible]

No.	Name	Subprofiles & Total	600	700	800	900	1000	1100	1200	1300	1400	1500
1	Administration	LIGHTING WH/HR/SQFT	0.055617	0.056352	0.048554	0.040452	0.051174	0.049562	0.053449	0.057928	0.059311	0.060382
1	Administration	MOTORS WH/HR/SQFT	0.005235	0.005336	0.001531	0.002183	0.002418	0.002549	0.002675	0.002755	0.002831	0.002931
1	Administration	MISSION WH/HR/SQFT	0.026252	0.026995	0.046833	0.040838	0.045295	0.045875	0.048827	0.051866	0.053965	0.053903
1	Administration	SUPPORT WH/HR/SQFT	0.036873	0.040052	0.053494	0.063696	0.062776	0.066459	0.063292	0.059412	0.059303	0.057507
1	Administration	TOTAL WH/HR/SQFT	0.123979	0.128736	0.150414	0.158171	0.161615	0.164447	0.168245	0.171962	0.175412	0.174724
2	Training	LIGHTING WH/HR/SQFT	0.029455	0.029047	0.045729	0.047199	0.044749	0.043543	0.045155	0.046049	0.046691	0.045149
2	Training	MOTORS WH/HR/SQFT	0.000497	0.000490	0.000398	0.000412	0.000389	0.000378	0.000393	0.000401	0.000407	0.000393
2	Training	MISSION WH/HR/SQFT	0.017240	0.016871	0.013141	0.013844	0.012673	0.012096	0.013195	0.013634	0.013949	0.013192
2	Training	SUPPORT WH/HR/SQFT	0.018971	0.018306	0.028903	0.019037	0.019856	0.020591	0.028487	0.019349	0.020150	0.019286
2	Training	TOTAL WH/HR/SQFT	0.066166	0.064715	0.088173	0.080493	0.077668	0.076609	0.087232	0.079434	0.081199	0.078021
3	Motor/Tank Maint/Repair Shop	LIGHTING WH/HR/SQFT	0.117346	0.114618	0.089277	0.100593	0.099368	0.110984	0.107593	0.115089	0.116297	0.131713
3	Motor/Tank Maint/Repair Shop	MOTORS WH/HR/SQFT	0.016061	0.016400	0.026361	0.016872	0.024458	0.019006	0.026755	0.019791	0.020022	0.022969
3	Motor/Tank Maint/Repair Shop	MISSION WH/HR/SQFT	0.051235	0.059327	0.061193	0.057719	0.057076	0.063172	0.061392	0.065326	0.074614	0.083988
3	Motor/Tank Maint/Repair Shop	SUPPORT WH/HR/SQFT	0.018462	0.019146	0.019376	0.021859	0.021668	0.027089	0.023803	0.021978	0.023790	0.023794
3	Motor/Tank Maint/Repair Shop	TOTAL WH/HR/SQFT	0.203105	0.209492	0.196214	0.197045	0.202571	0.220254	0.219544	0.222187	0.234725	0.262466
4	Storage	LIGHTING WH/HR/SQFT	0.035709	0.036845	0.034689	0.035135	0.036020	0.039603	0.039078	0.039286	0.041574	0.046138
4	Storage	MOTORS WH/HR/SQFT	0.058670	0.060515	0.056679	0.056919	0.058515	0.063623	0.063418	0.064182	0.067803	0.075817
4	Storage	MISSION WH/HR/SQFT	0.035709	0.036045	0.034689	0.035135	0.036020	0.039603	0.039078	0.039286	0.041574	0.046138
4	Storage	SUPPORT WH/HR/SQFT	0.056441	0.058217	0.054544	0.054804	0.056331	0.061291	0.061055	0.061765	0.065257	0.072935
4	Storage	TOTAL WH/HR/SQFT	0.186530	0.192423	0.180603	0.181994	0.186888	0.204123	0.202630	0.204519	0.216209	0.241030
5	Medical	LIGHTING WH/HR/SQFT	0.050587	0.040804	0.032687	0.109803	0.109066	0.106184	0.098099	0.107912	0.090666	0.099338
5	Medical	MOTORS WH/HR/SQFT	0.038705	0.031220	0.037875	0.044870	0.044577	0.043391	0.040087	0.044097	0.037049	0.040593
5	Medical	MISSION WH/HR/SQFT	0.161129	0.129971	0.041740	0.049448	0.049125	0.047816	0.044127	0.048596	0.040829	0.044735
5	Medical	SUPPORT WH/HR/SQFT	0.026556	0.021421	0.039775	0.047120	0.046813	0.045567	0.042098	0.046309	0.038908	0.042629
5	Medical	TOTAL WH/HR/SQFT	0.276978	0.223418	0.212079	0.251242	0.249601	0.242962	0.224462	0.246916	0.207454	0.227297
6	Family Housing	LIGHTING WH/HR/SQFT	0.081655	0.079979	0.090211	0.138281	0.153989	0.151964	0.147428	0.150608	0.149973	0.150504
6	Family Housing	MOTORS WH/HR/SQFT	0.054482	0.051597	0.050576	0.059054	0.066261	0.074414	0.081813	0.086592	0.088758	0.092318
6	Family Housing	MISSION WH/HR/SQFT	0.082952	0.088520	0.077024	0.147039	0.200176	0.318381	0.445265	0.486133	0.450952	0.389808
6	Family Housing	SUPPORT WH/HR/SQFT	0.004316	0.001454	0.006520	0.014527	0.021231	0.028126	0.034029	0.045044	0.054388	0.086875
6	Family Housing	TOTAL WH/HR/SQFT	0.223407	0.221553	0.224334	0.358903	0.441658	0.572886	0.708537	0.768378	0.744072	0.719506
7	Troop Housing	LIGHTING WH/HR/SQFT	0.004550	0.005053	0.006695	0.008403	0.007221	0.006099	0.005990	0.006043	0.006033	0.006042
7	Troop Housing	MOTORS WH/HR/SQFT	0.000913	0.000865	0.000848	0.000990	0.001111	0.001248	0.001372	0.001452	0.001488	0.001546
7	Troop Housing	MISSION WH/HR/SQFT	0.001393	0.001487	0.001294	0.002460	0.003359	0.005342	0.007470	0.008156	0.007566	0.006540
7	Troop Housing	SUPPORT WH/HR/SQFT	0.007354	0.007377	0.007789	0.011826	0.013467	0.014038	0.018681	0.016987	0.016236	0.016618
7	Troop Housing	TOTAL WH/HR/SQFT	0.014212	0.014783	0.016627	0.023689	0.025160	0.026728	0.033515	0.032639	0.031324	0.030749
8	Dining/Cafeteria/Snack Bar	LIGHTING WH/HR/SQFT	0.023101	0.038394	0.765785	1.387541	1.422059	1.412711	1.422558	1.422528	1.412841	1.412894
8	Dining/Cafeteria/Snack Bar	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
8	Dining/Cafeteria/Snack Bar	MISSION WH/HR/SQFT	2.664361	5.308718	5.173431	5.107111	6.837166	7.164327	6.818485	7.049499	6.788123	6.488992
8	Dining/Cafeteria/Snack Bar	SUPPORT WH/HR/SQFT	0.000664	0.001105	0.032967	0.026283	0.026330	0.034762	0.034742	0.034741	0.034765	0.034767
8	Dining/Cafeteria/Snack Bar	TOTAL WH/HR/SQFT	2.688128	5.348218	5.972184	6.520936	8.285576	8.611801	8.275785	8.506769	8.235730	7.936654
9	Commissary	LIGHTING WH/HR/SQFT	0.070390	0.075352	0.214263	0.431191	0.440938	0.465975	0.452190	0.487813	0.520990	0.470197
9	Commissary	MOTORS WH/HR/SQFT	4.561094	4.825239	4.872965	4.785636	4.906226	4.929412	5.049686	5.361395	5.466033	5.308786
9	Commissary	MISSION WH/HR/SQFT	0.005710	0.006149	0.011854	0.010005	0.013383	0.036655	0.037721	0.037283	0.036637	0.021126
9	Commissary	SUPPORT WH/HR/SQFT	0.020260	0.025070	0.026617	0.038060	0.032482	0.052012	0.050747	0.045301	0.044561	0.042066
9	Commissary	TOTAL WH/HR/SQFT	4.657455	4.931812	5.125699	5.264893	5.473031	5.484055	5.590345	5.931794	6.068222	5.842176
10	Cold Storage	LIGHTING WH/HR/SQFT	0.035640	0.031915	0.016961	0.015411	0.016752	0.016664	0.016130	0.016332	0.016590	0.015746
10	Cold Storage	MOTORS WH/HR/SQFT	0.548518	0.502862	0.514601	0.453035	0.501563	0.498927	0.535440	0.553937	0.466610	0.482830
10	Cold Storage	MISSION WH/HR/SQFT	0.050059	0.044828	0.048887	0.044367	0.048228	0.047974	0.046437	0.047018	0.047759	0.045330
10	Cold Storage	SUPPORT WH/HR/SQFT	0.020528	0.061458	0.020351	0.064264	0.023814	0.028402	0.065592	0.063616	0.023583	0.062146
10	Cold Storage	TOTAL WH/HR/SQFT	0.654747	0.641065	0.600822	0.577079	0.590359	0.591969	0.663601	0.680905	0.554543	0.606054
11	Heating Plant - Coal/Oil Fired	LIGHTING WH/HR/SQFT	0.193973	0.193318	0.179892	0.178335	0.178321	0.178382	0.178514	0.177578	0.176374	0.176922
11	Heating Plant - Coal/Oil Fired	MOTORS WH/HR/SQFT	4.030880	3.971198	3.996808	4.043051	4.108076	4.080399	4.071260	4.038139	4.034482	4.100563
11	Heating Plant - Coal/Oil Fired	MISSION WH/HR/SQFT	1.034584	1.034584	1.084879	1.084879	1.084879	1.084879	1.084879	1.084879	1.027651	1.027651
11	Heating Plant - Coal/Oil Fired	SUPPORT WH/HR/SQFT	0.039020	0.042742	0.041102	0.049890	0.045099	0.046747	0.047680	0.044823	0.045002	0.044206
11	Heating Plant - Coal/Oil Fired	TOTAL WH/HR/SQFT	5.298458	5.241844	5.302682	5.356156	5.416377	5.390409	5.382335	5.345421	5.283509	5.349343
12	Hutments	LIGHTING WH/HR/SQFT	0.079007	0.073678	0.110846	0.138804	0.138804	0.101526	0.101526	0.101526	0.101526	0.101526
12	Hutments	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
12	Hutments	MISSION WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
12	Hutments	SUPPORT WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
12	Hutments	TOTAL WH/HR/SQFT	0.079007	0.073678	0.110846	0.138804	0.138804	0.101526	0.101526	0.101526	0.101526	0.101526
13	Training Simulator	LIGHTING WH/HR/SQFT	0.038616	0.038616	0.038616	0.038616	0.038616	0.038616	0.038616	0.038616	0.038616	0.038616
13	Training Simulator	MOTORS WH/HR/SQFT	0.018761	0.018761	0.018761	0.018761	0.018761	0.018761	0.018761	0.018761	0.018761	0.018761
13	Training Simulator	MISSION WH/HR/SQFT	0.604270	0.569305	0.579687	0.623909	0.566345	0.544315	0.580755	0.529980	0.396834	0.450130
13	Training Simulator	SUPPORT WH/HR/SQFT	0.017617	0.031093	0.031093	0.026952	0.022811	0.019077	0.015343	0.023218	0.031093	0.022811
13	Training Simulator	TOTAL WH/HR/SQFT	0.679265	0.657776	0.668158	0.708239	0.646534	0.620770	0.653476	0.610576	0.485305	0.530320
14	Missile Equip Maint Shop	LIGHTING WH/HR/SQFT	0.323164	0.312223	0.253061	0.249297	0.248796	0.249115	0.249100	0.249694	0.248929	0.250076
14	Missile Equip Maint Shop	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
14	Missile Equip Maint Shop	MISSION WH/HR/SQFT	0.194918	0.214913	0.161935	0.189544	0.292768	0.227610	0.183541	0.164739	0.201439	0.159817
14	Missile Equip Maint Shop	SUPPORT WH/HR/SQFT	0.126732	0.145676	0.239794	0.247760	0.243892	0.246350	0.244245	0.246841	0.240934	0.249771
14	Missile Equip Maint Shop	TOTAL WH/HR/SQFT	0.644815	0.672813	0.654051	0.686603	0.785458	0.723075	0.676887	0.661275	0.691303	0.659664
15	Electronics/Electr Maint Shop	LIGHTING WH/HR/SQFT	0.036131	0.036131	0.036131	0.036131	0.036131	0.036131	0.036131	0.036131	0.036131	0.036131
15	Electronics/Electr Maint Shop	MOTORS WH/HR/SQFT	0.410162	0.410162	0.410162	0.410162	0.410162	0.410162	0.410162	0.410162	0.410162	0.410162
15	Electronics/Electr Maint Shop	MISSION WH/HR/SQFT	0.159240	0.159240	0.159240	0.159240	0.159240	0.159240	0.159240	0.159240	0.159240	0.159240
15	Electronics/Electr Maint Shop	SUPPORT WH/HR/SQFT	0.021019	0.021019	0.021019	0.021019	0.021019	0.021019	0.021019	0.021019	0.021019	0.021019
15	Electronics/Electr Maint Shop	TOTAL WH/HR/SQFT	0.626554	0.626554	0.626554	0.626554	0.626554	0.626554	0.626554	0.626554	0.626554	0.626554
16.2	Dining (Troops)	LIGHTING WH/HR/SQFT	0.096991	0.141247	0.146260	0.137103	0.137075	0.140110	0.139331	0.140121	0.109809	0.107416
16.2	Dining (Troops)	MOTORS WH/HR/SQFT	0.000733	0.000780	0.000780	0.000935	0.001098	0.001117	0.000922	0.001037	0.001046	0.000919
16.2	Dining (Troops)	MISSION WH/HR/SQFT	0.533884	1.103598	1.027231	1.356635	1.341272	1.131864	1.168599	1.323136	1.243789	1.015667
16.2	Dining (Troops)	SUPPORT WH/HR/SQFT	0.000049	0.000810	0.001557	0.001496	0.001506	0.001530	0.001503	0.001516	0.001534	0.001517
16.2	Dining (Troops)	TOTAL WH/HR/SQFT	0.631658	1.245437	1.175837	1.496250	1.480952	1.274622	1.310356	1.465811	1.356180	1.125521
17	School	LIGHTING WH/HR/SQFT	0.020167	0.019542	0.020343	0.018005	0.018689	0.018750	0.018865	0.018748	0.018707	0.018846
17	School	MOTORS WH/HR/SQFT	0.000646	0.000646	0.000969	0.000969	0.000969	0.000969	0.000969	0.000969	0.000969	0.000969
17	School	MISSION WH/HR/SQFT	0.000970	0.000914	0.001159	0.000906	0.000973	0.000981	0.000992	0.000980	0.000984	0.000990
17	School	SUPPORT WH/HR/SQFT	0.055120	0.053805	0.052891	0.050203	0.047313	0.049106	0.048216	0.047762	0.048061	0.048511
17	School	TOTAL WH/HR/SQFT	0.076904	0.074914	0.075358	0.071051	0.067946	0.069816	0.069043	0.068461	0.068804	0.069318
18	Telephone Exchange	LIGHTING WH/HR/SQFT	0.393466	0.393466	0.444107	0.444107	0.444107	0.444107	0.444107	0.444107	0.444107	0.444107
18	Telephone Exchange	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
18	Telephone Exchange	MISSION WH/HR/SQFT	1.478447	1.534593	1.600179	1.749326	1.749326	1.749479	1.749326	1.749326	1.749326	1.749326
18	Telephone Exchange	SUPPORT WH/HR/SQFT	0.060770	0.065864	0.076254	0.225141	0.149167	0.093447	0.293014	0.217039	0.081294	0.081294

FACILITY No.	Name	Subtotals & Totals	1600	1700	1800	1900	2000	2100	2200	2300	2400	SUM (WH/SF/DY)
1	Administration	LIGHTING WH/HR/SQFT	0.056555	0.057037	0.054298	0.055116	0.055238	0.057282	0.052010	0.050928	0.055177	1.33747[illegible]
1	Administration	MOTORS WH/HR/SQFT	0.005564	0.005811	0.006049	0.005254	0.005543	0.005360	0.005103	0.004849	0.005125	0.101[illegible]
1	Administration	MISSION WH/HR/SQFT	0.046368	0.023396	0.020417	0.026169	0.02[illegible]	0.028096	0.027564	0.025677	0.026926	0.855[illegible]
1	Administration	SUPPORT WH/HR/SQFT	0.055527	0.050217	0.052100	0.044[illegible]	0.045351	0.040119	0.039004	0.043826	0.040041	1.13515[illegible]
1	Administration	TOTAL WH/HR/SQFT	0.164011	0.145362	0.142965	0.13[illegible]	0.135920	0.131356	0.126683	0.125330	0.127271	3.43380[illegible]
2	Training	LIGHTING WH/HR/SQFT	0.044600	0.071171	0.033628	0.030449	0.039364	0.030287	0.029714	0.029080	0.030199	0.860964
2	Training	MOTORS WH/HR/SQFT	0.000388	0.000529	0.000576	0.000516	0.000496	0.000513	0.000502	0.000490	0.000511	0.01122[illegible]
2	Training	MISSION WH/HR/SQFT	0.012601	0.010790	0.021055	0.018138	0.017150	0.017992	0.017474	0.016872	0.017912	0.386[illegible]
2	Training	SUPPORT WH/HR/SQFT	0.028465	0.020618	0.019330	0.019063	0.019372	0.019021	0.018946	0.019874	0.018955	0.4865[illegible]
2	Training	TOTAL WH/HR/SQFT	0.086055	0.071109	0.074659	0.068167	0.066991	0.067814	0.066658	0.066285	0.067579	1.744965
3	Motor/Tank Maint/Repair Shop	LIGHTING WH/HR/SQFT	0.169713	0.169091	0.165890	0.169055	0.132607	0.130533	0.124890	0.116256	0.114898	2.949641
3	Motor/Tank Maint/Repair Shop	MOTORS WH/HR/SQFT	0.022392	0.019503	0.026443	0.026120	0.021722	0.027040	0.017390	0.023333	0.022981	0.517962
3	Motor/Tank Maint/Repair Shop	MISSION WH/HR/SQFT	0.082151	0.074074	0.071111	0.072500	0.076332	0.066919	0.054224	0.050804	0.050266	1.47656[illegible]
3	Motor/Tank Maint/Repair Shop	SUPPORT WH/HR/SQFT	0.026108	0.026322	0.025207	0.026421	0.027959	0.021480	0.018253	0.024016	0.019863	0.514214
3	Motor/Tank Maint/Repair Shop	TOTAL WH/HR/SQFT	0.300365	0.288991	0.288653	0.294127	0.258621	0.245974	0.214759	0.214410	0.208009	5.458408
4	Storage	LIGHTING WH/HR/SQFT	0.052661	0.050816	0.050622	0.051673	0.046023	0.043137	0.037600	0.038260	0.036690	0.961932
4	Storage	MOTORS WH/HR/SQFT	0.086765	0.083479	0.083381	0.084963	0.074706	0.071053	0.062036	0.061935	0.060086	1.576744
4	Storage	MISSION WH/HR/SQFT	0.052661	0.050816	0.050622	0.051673	0.046023	0.043137	0.037600	0.038260	0.036690	0.961932
4	Storage	SUPPORT WH/HR/SQFT	0.063454	0.080308	0.080201	0.081731	0.071922	0.068343	0.059664	0.059637	0.057815	1.5[illegible]7053
4	Storage	TOTAL WH/HR/SQFT	0.275541	0.265421	0.264827	0.270042	0.238676	0.225671	0.196902	0.198093	0.191283	5.0[illegible]663
5	Medical	LIGHTING WH/HR/SQFT	0.105597	0.066929	0.049303	0.051760	0.051324	0.054202	0.055076	0.054698	0.058343	1.[illegible]
5	Medical	MOTORS WH/HR/SQFT	0.043151	0.051208	0.037723	0.039603	0.039269	0.041853	0.042179	0.041851	0.044639	0.995324
5	Medical	MISSION WH/HR/SQFT	0.047554	0.052986	0.124234	0.153965	0.199349	0.237349	0.264013	0.219000	0.181487	3.009486
5	Medical	SUPPORT WH/HR/SQFT	0.045316	0.035135	0.025886	0.027173	0.026944	0.028717	0.028913	0.028715	0.030628	0.819686
5	Medical	TOTAL WH/HR/SQFT	0.241619	0.206260	0.237143	0.272502	0.316888	0.362616	0.390142	0.344265	0.315097	6.553721
6	Family Housing	LIGHTING WH/HR/SQFT	0.148313	0.301272	0.291466	0.292907	0.239935	0.285847	0.242538	0.205297	0.143013	3.797569
6	Family Housing	MOTORS WH/HR/SQFT	0.088058	0.065350	0.075656	0.076996	0.074542	0.074197	0.061900	0.073721	0.064545	1.677440
6	Family Housing	MISSION WH/HR/SQFT	0.490862	0.436499	0.353655	0.396946	0.300261	0.300534	0.271719	0.056696	0.101598	6.211802
6	Family Housing	SUPPORT WH/HR/SQFT	0.079664	0.157523	0.100695	0.145336	0.132702	0.130246	0.109975	0.154127	0.148935	1.456325
6	Family Housing	TOTAL WH/HR/SQFT	0.806899	0.980645	0.821476	0.912786	0.813442	0.790805	0.686134	0.489843	0.458092	13.14313
7	Troop Housing	LIGHTING WH/HR/SQFT	0.006349	0.010177	0.012792	0.012628	0.012843	0.012941	0.012215	0.010934	0.008564	0.184660
7	Troop Housing	MOTORS WH/HR/SQFT	0.001472	0.001431	0.001269	0.001291	0.001250	0.001244	0.001030	0.001236	0.001082	0.028135
7	Troop Housing	MISSION WH/HR/SQFT	0.008235	0.007123	0.005934	0.006660	0.005139	0.005044	0.004599	0.000953	0.001706	0.104246
7	Troop Housing	SUPPORT WH/HR/SQFT	0.015579	0.016500	0.018346	0.018663	0.014849	0.014923	0.011900	0.012588	0.011866	0.301379
7	Troop Housing	TOTAL WH/HR/SQFT	0.031631	0.035233	0.038342	0.033249	0.034082	0.034159	0.029721	0.025712	0.023219	0.618442
8	Dining/Cafeteria/Snack Bar	LIGHTING WH/HR/SQFT	1.420545	1.419352	0.826511	0.018553	0.018553	0.018553	0.018553	0.018553	0.018553	14.59091
8	Dining/Cafeteria/Snack Bar	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
8	Dining/Cafeteria/Snack Bar	MISSION WH/HR/SQFT	5.838967	5.395583	4.343659	2.181706	1.752226	1.701047	1.714844	1.725970	1.733981	94.46590
8	Dining/Cafeteria/Snack Bar	SUPPORT WH/HR/SQFT	0.038488	0.038456	0.024747	0.000534	0.000534	0.000534	0.000534	0.000534	0.000534	0.368693
8	Dining/Cafeteria/Snack Bar	TOTAL WH/HR/SQFT	7.298001	6.853392	5.195119	2.200793	1.771316	1.720135	1.733931	1.745056	1.753069	109.4255
9	Commissary	LIGHTING WH/HR/SQFT	0.449874	0.237827	0.084220	0.080410	0.081080	0.079151	0.070076	0.076027	0.073052	5.279549
9	Commissary	MOTORS WH/HR/SQFT	5.180374	5.382545	5.341514	5.059953	4.810927	4.751142	4.460938	4.342046	4.497706	118.6800
9	Commissary	MISSION WH/HR/SQFT	0.012997	0.010619	0.009632	0.009065	0.008539	0.006497	0.007494	0.005445	0.005210	0.311077
9	Commissary	SUPPORT WH/HR/SQFT	0.041104	0.035084	0.032827	0.041548	0.035582	0.027865	0.021585	0.035092	0.031612	0.7641[illegible]
9	Commissary	TOTAL WH/HR/SQFT	5.684355	5.666077	5.478195	5.192002	4.935929	4.864657	4.565074	4.459411	4.607581	125.0420
10	Cold Storage	LIGHTING WH/HR/SQFT	0.016506	0.030639	0.032300	0.035274	0.035064	0.031826	0.031211	0.034019	0.035062	0.6506[illegible]
10	Cold Storage	MOTORS WH/HR/SQFT	0.470265	0.420483	0.494307	0.557931	0.536664	0.460616	0.453089	0.491591	0.533644	12.02107
10	Cold Storage	MISSION WH/HR/SQFT	0.047517	0.043035	0.045369	0.049546	0.049250	0.044772	0.043839	0.047783	0.049248	1.130746
10	Cold Storage	SUPPORT WH/HR/SQFT	0.026290	0.060787	0.063394	0.027688	0.023707	0.018002	0.052764	0.023001	0.019890	0.865583
10	Cold Storage	TOTAL WH/HR/SQFT	0.560579	0.554945	0.635431	0.670442	0.644686	0.555340	0.581506	0.596395	0.637845	14.66803
11	Heating Plant - Coal/Oil Fired	LIGHTING WH/HR/SQFT	0.179186	0.181482	0.194801	0.193850	0.192896	0.193025	0.192708	0.194175	0.193602	4.495426
11	Heating Plant - Coal/Oil Fired	MOTORS WH/HR/SQFT	4.083587	4.024510	4.068019	3.937855	3.779430	3.621863	3.903509	3.950402	3.904194	95.62983
11	Heating Plant - Coal/Oil Fired	MISSION WH/HR/SQFT	1.027651	1.034584	1.034584	1.034584	1.034584	1.034584	1.034584	1.034584	1.034584	25.11096
11	Heating Plant - Coal/Oil Fired	SUPPORT WH/HR/SQFT	0.046212	0.047067	0.046783	0.046146	0.045127	0.044448	0.039606	0.046167	0.042370	1.033934
11	Heating Plant - Coal/Oil Fired	TOTAL WH/HR/SQFT	5.336637	5.287645	5.344189	5.212437	5.052038	5.093942	5.170409	5.225329	5.174752	126.2701
12	Hutments	LIGHTING WH/HR/SQFT	0.101526	0.092317	0.117168	0.117168	0.122438	0.127828	0.084337	0.084337	0.084337	2.401985
12	Hutments	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
12	Hutments	MISSION WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
12	Hutments	SUPPORT WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
12	Hutments	TOTAL WH/HR/SQFT	0.101526	0.092317	0.117168	0.117168	0.122438	0.127828	0.084337	0.084337	0.084337	2.401985
13	Training Simulator	LIGHTING WH/HR/SQFT	0.038616	0.038616	0.038616	0.038616	0.038616	0.038616	0.038616	0.038616	0.038616	0.926[illegible]
13	Training Simulator	MOTORS WH/HR/SQFT	0.018761	0.018761	0.018761	0.018761	0.018761	0.018761	0.018761	0.018761	0.018761	0.450276
13	Training Simulator	MISSION WH/HR/SQFT	0.451488	0.484244	0.459176	0.499566	0.513367	0.444136	0.479427	0.441204	0.540820	12.47457
13	Training Simulator	SUPPORT WH/HR/SQFT	0.023219	0.023625	0.012422	0.008281	0.004140	0.008281	0.012422	0.012422	0.008281	0.391477
13	Training Simulator	TOTAL WH/HR/SQFT	0.532084	0.565246	0.528977	0.565225	0.574886	0.509795	0.549227	0.511004	0.606480	14.24411
14	Missile Equip Maint Shop	LIGHTING WH/HR/SQFT	0.248508	0.294472	0.400149	0.400360	0.365293	0.340492	0.339968	0.320800	0.322247	7.282908
14	Missile Equip Maint Shop	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
14	Missile Equip Maint Shop	MISSION WH/HR/SQFT	0.171929	0.193950	0.147913	0.164540	0.202413	0.202618	0.216257	0.210709	0.235983	4.832825
14	Missile Equip Maint Shop	SUPPORT WH/HR/SQFT	0.237683	0.148388	0.127081	0.125189	0.126107	0.126220	0.126086	0.126128	0.126498	4.135365
14	Missile Equip Maint Shop	TOTAL WH/HR/SQFT	0.658121	0.636817	0.675144	0.690090	0.693713	0.669331	0.682312	0.657638	0.684728	16.25111
15	Electronics/Electr Maint Shop	LIGHTING WH/HR/SQFT	0.036131	0.036131	0.036131	0.036131	0.036131	0.036131	0.036131	0.036131	0.036131	0.867154
15	Electronics/Electr Maint Shop	MOTORS WH/HR/SQFT	0.410162	0.410162	0.410162	0.410162	0.410162	0.410162	0.410162	0.410162	0.410162	9.843910
15	Electronics/Electr Maint Shop	MISSION WH/HR/SQFT	0.159240	0.159240	0.159240	0.159240	0.159240	0.159240	0.159240	0.159240	0.159240	3.821769
15	Electronics/Electr Maint Shop	SUPPORT WH/HR/SQFT	0.021019	0.021019	0.021019	0.021019	0.021019	0.021019	0.021019	0.021019	0.021019	0.504475
15	Electronics/Electr Maint Shop	TOTAL WH/HR/SQFT	0.626554	0.626554	0.626554	0.626554	0.626554	0.626554	0.626554	0.626554	0.626554	15.03731
16-2	Dining (Troops)	LIGHTING WH/HR/SQFT	0.106120	0.122318	0.152111	0.147001	0.099586	0.097005	0.092624	0.066905	0.056159	2.48927[illegible]
16-2	Dining (Troops)	MOTORS WH/HR/SQFT	0.001040	0.001015	0.000888	0.000780	0.000733	0.000733	0.000733	0.000733	0.000733	0.020455
16-2	Dining (Troops)	MISSION WH/HR/SQFT	1.086222	1.239453	0.881799	0.719721	0.597692	0.590418	0.541390	0.558421	0.513120	20.13580
16-2	Dining (Troops)	SUPPORT WH/HR/SQFT	0.002822	0.002830	0.004114	0.004734	0.005411	0.005411	0.005411	0.002730	0.000049	0.046782
16-2	Dining (Troops)	TOTAL WH/HR/SQFT	1.196205	1.370611	1.043914	0.873037	0.703424	0.694444	0.645210	0.628790	0.570062	22.69[illegible]
17	School	LIGHTING WH/HR/SQFT	0.018314	0.019005	0.019594	0.019362	0.019685	0.019784	0.020006	0.019717	0.019819	0.469222
17	School	MOTORS WH/HR/SQFT	0.000364	0.000646	0.000646	0.000646	0.000646	0.000646	0.000646	0.000646	0.000646	0.010427
17	School	MISSION WH/HR/SQFT	0.000[illegible]	0.001000	0.001072	0.001108	0.001232	0.001245	0.001125	0.001009	0.000942	0.024662
17	School	SUPPORT WH/HR/SQFT	0.048740	0.054407	0.054201	0.053047	0.053624	0.053101	0.049849	0.054604	0.052100	1.250646
17	School	TOTAL WH/HR/SQFT	0.068958	0.075154	0.075514	0.074245	0.075189	0.074777	0.071707	0.075978	0.073508	1.751159
18	Telephone Exchange	LIGHTING WH/HR/SQFT	0.444107	0.393466	0.393466	0.393466	0.393466	0.393466	0.393466	0.393466	0.393466	9.[illegible]
18	Telephone Exchange	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
18	Telephone Exchange	MISSION WH/HR/SQFT	1.[illegible]	1.[illegible]	1.[illegible]	1.661806	1.661806	1.661806	1.661806	1.661806	1.661806	39.414[illegible]
18	Telephone Exchange	SUPPORT WH/HR/SQFT	0.0[illegible]	0.07[illegible]	0.[illegible]	0.[illegible]	0.076051	0.0[illegible]	0.0[illegible]	0.076051	0.062944	[illegible]

PROFILE

WKDAY

No.	Name	Subprofiles & Total	100	200	300	400	500	600	700	800	900	1000
18	Telephone Exchange	TOTAL WH/HR/SQFT	1.969990	1.974041	1.970914	1.966663	2.036111	2.032060	2.096334	2.893471	3.678943	3.675580
19.4	Fire Station	LIGHTING WH/HR/SQFT	0.263661	0.267401	0.212906	0.218305	0.175607	0.157924	0.163600	0.451482	0.417614	0.541292
19.4	Fire Station	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
19.4	Fire Station	MISSION WH/HR/SQFT	0.002003	0.002003	0.002003	0.002003	0.002003	0.002003	0.002003	0.222487	0.222487	0.222487
19.4	Fire Station	SUPPORT WH/HR/SQFT	0.377415	0.335336	0.388682	0.372405	0.407427	0.426021	0.851769	1.393375	0.698092	0.580402
19.4	Fire Station	TOTAL WH/HR/SQFT	0.643079	0.604740	0.603674	0.590213	0.585538	0.581948	1.017372	2.067346	1.338195	1.344183
20.1	Service Station	LIGHTING WH/HR/SQFT	0.457516	0.457516	0.457516	0.457516	0.457516	0.457516	0.457516	0.457516	0.228758	0.104248
20.1	Service Station	MOTORS WH/HR/SQFT	0.133333	0.133333	0.133333	0.133333	0.133333	0.133333	0.224754	0.377124	0.224754	0.469852
20.1	Service Station	MISSION WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0.004084
20.1	Service Station	SUPPORT WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0.099183
20.1	Service Station	TOTAL WH/HR/SQFT	0.590849	0.590849	0.590849	0.590849	0.590849	0.590849	0.682271	0.834640	0.453513	0.677369
21	Training Aids Center	LIGHTING WH/HR/SQFT	0.046171	0.045956	0.047029	0.046064	0.046171	0.045581	0.050472	0.074365	0.099401	0.103295
21	Training Aids Center	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
21	Training Aids Center	MISSION WH/HR/SQFT	0.001027	0.001022	0.001046	0.001025	0.001027	0.001014	0.000821	0.006688	0.029892	0.027589
21	Training Aids Center	SUPPORT WH/HR/SQFT	0.028720	0.028586	0.029253	0.028653	0.028720	0.028353	0.022950	0.044772	0.041122	0.042733
21	Training Aids Center	TOTAL WH/HR/SQFT	0.075919	0.075566	0.077330	0.075742	0.075919	0.074949	0.074243	0.125826	0.170417	0.173617
22.1	POL Pump Station	LIGHTING WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
22.1	POL Pump Station	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	10.41628	10.41628	10.41628
22.1	POL Pump Station	MISSION WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
22.1	POL Pump Station	SUPPORT WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
22.1	POL Pump Station	TOTAL WH/HR/SQFT	0	0	0	0	0	0	0	10.41628	10.41628	10.41628
23	Fac Engr Maint Shop	LIGHTING WH/HR/SQFT	0.021874	0.021874	0.021874	0.021874	0.021874	0.021874	0.021874	0.113869	0.242669	0.242669
23	Fac Engr Maint Shop	MOTORS WH/HR/SQFT	0.151435	0.151435	0.151435	0.151435	0.151435	0.151435	0.151435	0.277915	0.277915	0.277915
23	Fac Engr Maint Shop	MISSION WH/HR/SQFT	0.036884	0.036884	0.036884	0.036884	0.036884	0.036884	0.036884	0.495178	0.495178	0.495178
23	Fac Engr Maint Shop	SUPPORT WH/HR/SQFT	0.023992	0.031032	0.028616	0.132540	0.032171	0.028616	0.137303	0.215546	0.156656	0.156656
23	Fac Engr Maint Shop	TOTAL WH/HR/SQFT	0.234187	0.241227	0.238811	0.342735	0.242366	0.238811	0.347498	1.102510	1.172419	1.172419
24	Chapel	LIGHTING WH/HR/SQFT	0.026043	0.026043	0.026043	0.026043	0.026043	0.026043	0.026043	0.085537	0.128857	0.123231
24	Chapel	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
24	Chapel	MISSION WH/HR/SQFT	0.000937	0.000937	0.000937	0.000937	0.000937	0.000937	0.012658	0.053211	0.039733	0.028012
24	Chapel	SUPPORT WH/HR/SQFT	0.100680	0.113104	0.113104	0.153775	0.119316	0.113104	0.159987	0.193789	0.226607	0.191445
24	Chapel	TOTAL WH/HR/SQFT	0.127661	0.140085	0.140085	0.180756	0.146297	0.140085	0.198688	0.332539	0.395197	0.342689
25	Laundry	LIGHTING WH/HR/SQFT	0.174977	0.175159	0.178027	0.179741	0.177925	0.176530	0.185103	0.278068	0.394630	0.429395
25	Laundry	MOTORS WH/HR/SQFT	0.084050	0.083509	0.083520	0.083527	0.109908	0.116522	0.147372	0.164354	0.164783	0.165101
25	Laundry	MISSION WH/HR/SQFT	0.702303	0.706488	0.694911	0.713052	0.689341	0.652130	0.636860	0.930357	1.450996	1.667864
25	Laundry	SUPPORT WH/HR/SQFT	0.396971	0.387510	0.385461	0.383705	0.386341	0.382693	0.398340	0.435181	0.464333	0.487520
25	Laundry	TOTAL WH/HR/SQFT	1.358304	1.352668	1.341922	1.360028	1.363516	1.328076	1.367677	1.807961	2.474744	2.749882
26	Bank	LIGHTING WH/HR/SQFT	0.000495	0.000713	0.000792	0.000462	0.001089	0.000891	0.007164	0.112659	0.304652	0.360068
26	Bank	MOTORS WH/HR/SQFT	0.001658	0.002388	0.002654	0.001548	0.003649	0.002986	0.040121	0.014535	0.010096	0.007634
26	Bank	MISSION WH/HR/SQFT	0	0	0	0	0	0	0	0.094212	0.127634	0.178098
26	Bank	SUPPORT WH/HR/SQFT	0.001114	0.001604	0.001782	0.001039	0.002451	0.002005	0.016120	0.165571	0.154208	0.082777
26	Bank	TOTAL WH/HR/SQFT	0.003268	0.004706	0.005229	0.003050	0.007190	0.005883	0.063406	0.386978	0.596592	0.628578
27	Bowling Center	LIGHTING WH/HR/SQFT	0.277141	0.277141	0.277141	0.277141	0.277141	0.277141	0.217985	0.238782	0.299017	0.299017
27	Bowling Center	MOTORS WH/HR/SQFT	0.232359	0.199119	0.199119	0.199119	0.199119	0.199119	0.199119	0.199119	0.214411	0.248859
27	Bowling Center	MISSION WH/HR/SQFT	0.000321	0.000321	0.000321	0.000321	0.000321	0.000321	0.035735	0.071146	0.071148	0.071148
27	Bowling Center	SUPPORT WH/HR/SQFT	0.369824	0.386681	0.328083	0.708621	0.296654	0.354487	0.687373	0.754761	0.718530	0.407214
27	Bowling Center	TOTAL WH/HR/SQFT	0.879648	0.863264	0.805431	1.185204	0.773237	0.831070	1.140213	1.263812	1.303108	1.026240
28	Lunch Room	LIGHTING WH/HR/SQFT	0.005865	0.005865	0.005865	0.005865	0.005865	0.008524	0.067363	0.215784	0.253156	0.250044
28	Lunch Room	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
28	Lunch Room	MISSION WH/HR/SQFT	0.267499	0.284804	0.272986	0.271773	0.270611	0.907931	1.226779	1.085455	1.035825	1.112781
28	Lunch Room	SUPPORT WH/HR/SQFT	0.000084	0.000084	0.000084	0.000084	0.000085	0.000124	0.000085	0.003751	0.003751	0.003755
28	Lunch Room	TOTAL WH/HR/SQFT	0.273449	0.290754	0.278936	0.277722	0.276562	0.916579	1.294227	1.304990	1.292733	1.366581
29	Child Support Service Ctr	LIGHTING WH/HR/SQFT	0.247957	0.247957	0.247957	0.247957	0.247957	0.247957	0.424356	0.829896	0.831975	0.831975
29	Child Support Service Ctr	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
29	Child Support Service Ctr	MISSION WH/HR/SQFT	0	0	0	0	0	0	0.013226	0.033303	0.033303	0.034081
29	Child Support Service Ctr	SUPPORT WH/HR/SQFT	0.142571	0.142571	0.142571	0.142571	0.142571	0.142571	0.354276	0.987691	0.625390	0.625390
29	Child Support Service Ctr	TOTAL WH/HR/SQFT	0.390528	0.390528	0.390528	0.390528	0.390528	0.390528	0.791859	1.850891	1.490669	1.491447
30	Exchange Retail/Sales	LIGHTING WH/HR/SQFT	0.088659	0.081943	0.081196	0.080913	0.083266	0.076232	0.077752	0.754387	1.223253	1.576843
30	Exchange Retail/Sales	MOTORS WH/HR/SQFT	0.000464	0.000465	0.000475	0.000484	0.000480	0.000468	0.000438	0.000436	0.000445	0.000451
30	Exchange Retail/Sales	MISSION WH/HR/SQFT	0.243490	0.234470	0.239714	0.241315	0.238024	0.233014	0.225010	0.256805	0.229966	0.317181
30	Exchange Retail/Sales	SUPPORT WH/HR/SQFT	0.130157	0.141559	0.135032	0.133135	0.137393	0.139238	0.170501	0.217221	0.218782	0.217266
30	Exchange Retail/Sales	TOTAL WH/HR/SQFT	0.462972	0.458439	0.456419	0.455848	0.459165	0.448951	0.473703	1.228850	1.672447	2.111742
31	Exchange Branch	LIGHTING WH/HR/SQFT	0.129048	0.129048	0.129048	0.129048	0.129048	0.129048	0.129048	0.129048	0.327907	0.611396
31	Exchange Branch	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
31	Exchange Branch	MISSION WH/HR/SQFT	0.000316	0.000316	0.000316	0.000316	0.000316	0.000316	0.000316	0.000316	0.000712	0.003879
31	Exchange Branch	SUPPORT WH/HR/SQFT	0.069577	0.069577	0.062831	0.059095	0.059727	0.057827	0.062991	0.096179	0.258226	0.195005
31	Exchange Branch	TOTAL WH/HR/SQFT	0.198942	0.198942	0.192197	0.188461	0.189093	0.187193	0.192357	0.225544	0.586847	0.810284
32	Arts/Crafts/Skill Dev Ctr	LIGHTING WH/HR/SQFT	0.018659	0.015468	0.016453	0.017632	0.015142	0.015258	0.014880	0.003292	0.010492	0.012657
32	Arts/Crafts/Skill Dev Ctr	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
32	Arts/Crafts/Skill Dev Ctr	MISSION WH/HR/SQFT	0.004024	0.003300	0.003526	0.003794	0.003624	0.003251	0.003163	0.004971	0.015987	0.019302
32	Arts/Crafts/Skill Dev Ctr	SUPPORT WH/HR/SQFT	0.001608	0.006444	0.005476	0.003928	0.006676	0.006749	0.006599	0.018324	0.013767	0.014227
32	Arts/Crafts/Skill Dev Ctr	TOTAL WH/HR/SQFT	0.024293	0.025213	0.025456	0.025355	0.025043	0.024859	0.024643	0.026589	0.040247	0.046187
33	Club/Youth/Scout Bldg	LIGHTING WH/HR/SQFT	0.044004	0.044010	0.044042	0.043753	0.044030	0.044456	0.212941	0.208636	0.221200	0.197712
33	Club/Youth/Scout Bldg	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
33	Club/Youth/Scout Bldg	MISSION WH/HR/SQFT	0.000222	0.000222	0.000222	0.000222	0.000222	0.000222	0.000222	0.000801	0.002384	0.004211
33	Club/Youth/Scout Bldg	SUPPORT WH/HR/SQFT	0.161698	0.154605	0.159031	0.155487	0.157461	0.160648	0.221192	0.437413	0.301521	0.247960
33	Club/Youth/Scout Bldg	TOTAL WH/HR/SQFT	0.205926	0.198876	0.203296	0.199463	0.201715	0.205025	0.434357	0.646851	0.525106	0.449883
34	Community Center	LIGHTING WH/HR/SQFT	0.032763	0.032763	0.032763	0.032763	0.032764	0.032763	0.032763	0.071153	0.128075	0.128075
34	Community Center	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
34	Community Center	MISSION WH/HR/SQFT	0	0	0	0	0	0	0	0.054797	0.143241	0.143241
34	Community Center	SUPPORT WH/HR/SQFT	0	0.075703	0.075703	0.050469	0.100938	0.075703	0.075704	0.166575	0.250512	0.260854
34	Community Center	TOTAL WH/HR/SQFT	0.032763	0.108467	0.108467	0.083232	0.133702	0.108467	0.108467	0.292527	0.521829	0.532171
35	Gymnasium/Rec Bldg	LIGHTING WH/HR/SQFT	0.093702	0.091116	0.090540	0.094555	0.099088	0.124236	0.646629	0.629612	0.567101	0.605411
35	Gymnasium/Rec Bldg	MOTORS WH/HR/SQFT	0.365300	0.354066	0.360455	0.368162	0.422883	1.056563	1.288277	1.326102	1.283017	1.276481
35	Gymnasium/Rec Bldg	MISSION WH/HR/SQFT	0.000208	0.000208	0.000208	0.000208	0.000208	0.035987	0.120993	0.140780	0.260941	0.253177
35	Gymnasium/Rec Bldg	SUPPORT WH/HR/SQFT	0.009971	0.011056	0.009963	0.010015	0.011166	0.041749	0.064044	0.071660	0.098225	0.106517
35	Gymnasium/Rec Bldg	TOTAL WH/HR/SQFT	0.469182	0.462247	0.461176	0.472941	0.535342	1.403547	2.120944	2.168156	2.209285	2.24[illegible]
36	Library	LIGHTING WH/HR/SQFT	0.072200	0.071555	0.072700	0.073229	0.072536	0.074206	0.068247	0.069501	0.179285	0.276[illegible]
36	Library	MOTORS WH/HR/SQFT	0.015015	0.015002	0.015049	0.015012	0.015013	0.015031	0.014270	0.014259	0.016222	0.01[illegible]

P R O F I L E

No.	Name	Subprofiles & Total	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000
18	Telephone Exchange	TOTAL WH/HR/SQFT	3.663172	3.651293	3.663129	3.663234	3.654518	2.805832	2.323691	2.298506	2.122725	2.116674
19.4	Fire Station	LIGHTING WH/HR/SQFT	0.431527	0.434067	0.433161	0.466368	0.440831	0.419412	0.426867	0.433690	0.465284	0.395358
19.4	Fire Station	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
19.4	Fire Station	MISSION WH/HR/SQFT	0.222487	0.222487	0.222487	0.222487	0.222487	0.222487	0.002003	0.002003	0.002003	0.002003
19.4	Fire Station	SUPPORT WH/HR/SQFT	0.522701	1.052003	0.856126	0.840843	0.656802	0.655543	0.993600	1.204517	1.056042	1.128616
19.4	Fire Station	TOTAL WH/HR/SQFT	1.176717	1.710210	1.517026	1.529050	1.320121	1.297450	1.422472	1.640211	1.523330	1.526267
20.1	Service Station	LIGHTING WH/HR/SQFT	0.170588	0.170588	0.170588	0.170588	0.170588	0.363398	0.791503	1.020261	0.504575	0.457516
20.1	Service Station	MOTORS WH/HR/SQFT	1.023856	1.023856	1.023856	0.728758	0.728758	1.023856	1.023856	1.084803	0.347303	0.224754
20.1	Service Station	MISSION WH/HR/SQFT	0.018382	0.018382	0.018382	0.018382	0.018382	0.018382	0.018382	0.018382	0.006127	0
20.1	Service Station	SUPPORT WH/HR/SQFT	0.053594	0.200653	0.102614	0.053594	0.053594	0.053594	0.053594	0.004575	0	0
20.1	Service Station	TOTAL WH/HR/SQFT	1.266421	1.413480	1.315441	1.021323	1.021323	1.459232	1.887336	2.128022	0.858006	0.682271
21	Training Aids Center	LIGHTING WH/HR/SQFT	0.102788	0.105696	0.105387	0.096646	0.089697	0.099100	0.080017	0.067943	0.057003	0.051641
21	Training Aids Center	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
21	Training Aids Center	MISSION WH/HR/SQFT	0.021353	0.020142	0.020225	0.025737	0.023922	0.008587	0.001058	0.001512	0.001268	0.001149
21	Training Aids Center	SUPPORT WH/HR/SQFT	0.041522	0.041668	0.042573	0.039982	0.037107	0.040032	0.030518	0.042263	0.035458	0.032122
21	Training Aids Center	TOTAL WH/HR/SQFT	0.165664	0.167507	0.168186	0.162366	0.150727	0.147720	0.121594	0.111718	0.093730	0.084913
22.1	POL Pump Station	LIGHTING WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
22.1	POL Pump Station	MOTORS WH/HR/SQFT	10.41628	10.41628	10.41628	10.41628	10.41628	10.41628	10.41628	0	0	0
22.1	POL Pump Station	MISSION WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
22.1	POL Pump Station	SUPPORT WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
22.1	POL Pump Station	TOTAL WH/HR/SQFT	10.41628	10.41628	10.41628	10.41628	10.41628	10.41628	10.41628	0	0	0
23	Fac Engr Maint Shop	LIGHTING WH/HR/SQFT	0.242669	0.242669	0.242669	0.242669	0.242669	0.242669	0.158821	0.046493	0.021874	0.021874
23	Fac Engr Maint Shop	MOTORS WH/HR/SQFT	0.277915	0.277915	0.277915	0.277915	0.277915	0.277915	0.151435	0.151435	0.151435	0.151435
23	Fac Engr Maint Shop	MISSION WH/HR/SQFT	0.495178	0.495178	0.495178	0.495178	0.495178	0.495178	0.036884	0.036884	0.036884	0.036884
23	Fac Engr Maint Shop	SUPPORT WH/HR/SQFT	0.151418	0.255936	0.191466	0.151863	0.149937	0.221448	0.149955	0.154971	0.077728	0.043974
23	Fac Engr Maint Shop	TOTAL WH/HR/SQFT	1.167181	1.271699	1.207229	1.167657	1.165701	1.237211	0.497097	0.389785	0.287922	0.254169
24	Chapel	LIGHTING WH/HR/SQFT	0.123231	0.123231	0.123231	0.123231	0.123231	0.123231	0.031669	0.026043	0.026043	0.026043
24	Chapel	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
24	Chapel	MISSION WH/HR/SQFT	0.016291	0.016291	0.016291	0.016291	0.016291	0.016291	0.000937	0.000937	0.000937	0.000937
24	Chapel	SUPPORT WH/HR/SQFT	0.191445	0.238328	0.191445	0.238328	0.191445	0.226607	0.151313	0.186124	0.125528	0.131740
24	Chapel	TOTAL WH/HR/SQFT	0.330968	0.377851	0.330968	0.377851	0.330968	0.366130	0.183920	0.213105	0.152509	0.158721
25	Laundry	LIGHTING WH/HR/SQFT	0.431809	0.442071	0.452779	0.476784	0.471188	0.482537	0.482767	0.480752	0.467432	0.474176
25	Laundry	MOTORS WH/HR/SQFT	0.165123	0.165596	0.166112	0.166419	0.166779	0.166945	0.166496	0.166020	0.165563	0.165140
25	Laundry	MISSION WH/HR/SQFT	1.739860	1.794699	1.879808	2.195038	2.101560	2.206948	2.273954	2.302477	2.376769	2.743919
25	Laundry	SUPPORT WH/HR/SQFT	0.675165	0.505310	0.509229	0.516659	0.515465	0.528671	0.528794	0.514898	0.476511	0.464646
25	Laundry	TOTAL WH/HR/SQFT	3.011959	2.907677	3.007929	3.354902	3.254993	3.385103	3.452012	3.464149	3.486277	3.846164
26	Bank	LIGHTING WH/HR/SQFT	0.271511	0.266117	0.254567	0.274180	0.208296	0.252472	0.159008	0.101084	0.060187	0.014743
26	Bank	MOTORS WH/HR/SQFT	0.006543	0.006991	0.003343	0.003601	0.003779	0.004623	0.002911	0.004844	0.004774	0.001559
26	Bank	MISSION WH/HR/SQFT	0.086737	0.080162	0.060465	0.063966	0.044048	0.021607	0.013359	0.008063	0	0
26	Bank	SUPPORT WH/HR/SQFT	0.080526	0.111005	0.107005	0.125796	0.130363	0.115932	0.014777	0.024587	0.007759	0.001253
26	Bank	TOTAL WH/HR/SQFT	0.445319	0.464276	0.425382	0.467544	0.386488	0.394636	0.190057	0.138580	0.072721	0.017555
27	Bowling Center	LIGHTING WH/HR/SQFT	0.399204	1.290591	1.290591	1.290591	1.290591	1.290591	1.290591	1.330028	1.389185	1.448341
27	Bowling Center	MOTORS WH/HR/SQFT	0.252561	0.301496	0.301496	0.301496	0.301496	0.301496	0.301496	0.301496	0.301496	0.301496
27	Bowling Center	MISSION WH/HR/SQFT	0.313247	0.561784	0.690560	0.690560	0.619733	0.975154	1.330575	1.459351	1.814772	1.814772
27	Bowling Center	SUPPORT WH/HR/SQFT	1.176006	3.295115	3.391156	2.886825	2.494078	2.442509	2.736363	2.485250	2.121748	2.037349
27	Bowling Center	TOTAL WH/HR/SQFT	2.141020	5.448987	5.673803	5.169472	4.705899	5.009752	5.659026	5.576127	5.627203	5.601959
28	Lunch Room	LIGHTING WH/HR/SQFT	0.248667	0.253964	0.252534	0.250163	0.248935	0.250567	0.252113	0.250766	0.250713	0.249541
28	Lunch Room	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
28	Lunch Room	MISSION WH/HR/SQFT	0.931087	1.149528	1.282171	1.240728	0.964534	1.013007	0.804692	0.870615	0.789886	0.809249
28	Lunch Room	SUPPORT WH/HR/SQFT	0.005630	0.007542	0.005641	0.003714	0.003730	0.005656	0.006232	0.005600	0.005819	0.005830
28	Lunch Room	TOTAL WH/HR/SQFT	1.185386	1.411036	1.540348	1.494606	1.217199	1.269227	1.063038	1.126982	1.046419	1.064621
29	Child Support Service Ctr	LIGHTING WH/HR/SQFT	0.831975	0.831975	0.831975	0.831975	0.831975	0.831975	0.831975	0.416104	0.284368	0.247957
29	Child Support Service Ctr	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
29	Child Support Service Ctr	MISSION WH/HR/SQFT	0.034081	0.033303	0.033303	0.033303	0.034081	0.034081	0.026452	0.013226	0.000124	0
29	Child Support Service Ctr	SUPPORT WH/HR/SQFT	0.710509	1.112095	0.762890	0.730152	0.677271	0.625390	0.660311	0.429356	0.361697	0.142571
29	Child Support Service Ctr	TOTAL WH/HR/SQFT	1.576565	1.977374	1.628168	1.595430	1.543327	1.491447	1.518739	0.858686	0.646190	0.390528
30	Exchange Retail/Sales	LIGHTING WH/HR/SQFT	1.648497	1.730288	1.728136	1.732190	1.719841	1.647055	1.702210	1.481277	0.455305	0.092506
30	Exchange Retail/Sales	MOTORS WH/HR/SQFT	0.000870	0.000882	0.000869	0.000901	0.000863	0.000884	0.000873	0.000431	0.000432	0.000431
30	Exchange Retail/Sales	MISSION WH/HR/SQFT	0.337735	0.337341	0.321238	0.335537	0.305725	0.320434	0.311795	0.276871	0.210410	0.266176
30	Exchange Retail/Sales	SUPPORT WH/HR/SQFT	0.225537	0.222881	0.217669	0.213168	0.206805	0.211542	0.211522	0.173387	0.148070	0.145346
30	Exchange Retail/Sales	TOTAL WH/HR/SQFT	2.212641	2.291393	2.267914	2.281797	2.234242	2.179918	2.226402	1.931968	0.814819	0.504463
31	Exchange Branch	LIGHTING WH/HR/SQFT	0.809655	0.982353	0.982353	0.982353	0.982353	0.982353	0.982353	0.982353	0.611589	0.123148
31	Exchange Branch	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
31	Exchange Branch	MISSION WH/HR/SQFT	0.008741	0.591220	0.756969	0.756969	0.756969	0.756969	0.756969	0.674213	0.108558	0.005516
31	Exchange Branch	SUPPORT WH/HR/SQFT	0.136076	0.300106	0.291307	0.303620	0.226539	0.307761	0.313210	0.324007	0.347568	0.222517
31	Exchange Branch	TOTAL WH/HR/SQFT	0.954473	1.873760	2.030630	2.042943	1.965862	2.047104	2.052533	1.980575	1.067716	0.351182
32	Arts/Crafts/Skill Dev Ctr	LIGHTING WH/HR/SQFT	0.016739	0.007224	0.028717	0.036213	0.035372	0.037329	0.052422	0.071543	0.137357	0.126550
32	Arts/Crafts/Skill Dev Ctr	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
32	Arts/Crafts/Skill Dev Ctr	MISSION WH/HR/SQFT	0.025423	0.010863	0.009551	0.012044	0.011773	0.012424	0.033051	0.106019	0.272123	0.311379
32	Arts/Crafts/Skill Dev Ctr	SUPPORT WH/HR/SQFT	0.014227	0.059839	0.003908	0.003980	0.003544	0.003866	0.035633	0.051322	0.015630	0.019341
32	Arts/Crafts/Skill Dev Ctr	TOTAL WH/HR/SQFT	0.056389	0.077927	0.042177	0.052238	0.050690	0.053620	0.121107	0.228885	0.425112	0.457272
33	Club/Youth/Scout Bldg	LIGHTING WH/HR/SQFT	0.193704	0.191293	0.191545	0.201023	0.327815	0.373627	0.360879	0.360156	0.279031	0.214612
33	Club/Youth/Scout Bldg	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
33	Club/Youth/Scout Bldg	MISSION WH/HR/SQFT	0.003815	0.003429	0.003557	0.003694	0.003854	0.003613	0.002451	0.002308	0.000708	0.000708
33	Club/Youth/Scout Bldg	SUPPORT WH/HR/SQFT	0.195296	0.332816	0.199032	0.151736	0.207723	0.425645	0.531067	0.467450	0.168740	0.169017
33	Club/Youth/Scout Bldg	TOTAL WH/HR/SQFT	0.392816	0.527543	0.394135	0.356454	0.539393	0.802886	0.894798	0.829915	0.448480	0.384037
34	Community Center	LIGHTING WH/HR/SQFT	0.128075	0.128075	0.128075	0.128075	0.128075	0.071153	0.032763	0.032763	0.032763	0.032763
34	Community Center	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
34	Community Center	MISSION WH/HR/SQFT	0.143241	0.143241	0.143241	0.143241	0.143241	0.064450	0	0	0	0
34	Community Center	SUPPORT WH/HR/SQFT	0.220726	0.241411	0.317114	0.245961	0.220726	0.217045	0.259370	0.355766	0.330532	0.284613
34	Community Center	TOTAL WH/HR/SQFT	0.492044	0.512728	0.588432	0.517279	0.492044	0.352648	0.292142	0.388530	0.363295	0.317376
35	Gymnasium/ Rec Bldg	LIGHTING WH/HR/SQFT	0.572200	0.590139	0.626029	0.651962	0.651349	0.696636	0.713254	0.729976	0.740504	0.750261
35	Gymnasium/ Rec Bldg	MOTORS WH/HR/SQFT	1.276192	1.277194	1.276367	1.275757	1.269005	1.265005	1.281810	1.285463	1.288045	1.293565
35	Gymnasium/ Rec Bldg	MISSION WH/HR/SQFT	0.250262	0.245814	0.245883	0.258116	0.256015	0.247903	0.240063	0.241030	0.241375	0.241677
35	Gymnasium/ Rec Bldg	SUPPORT WH/HR/SQFT	0.107853	0.122042	0.123577	0.120861	0.117032	0.139320	0.148750	0.158494	0.159752	0.161767
35	Gymnasium/ Rec Bldg	TOTAL WH/HR/SQFT	2.207529	2.235191	2.271857	2.306697	2.294203	2.349545	2.384678	2.414965	2.429679	2.447271
36	Library	LIGHTING WH/HR/SQFT	0.340720	0.692242	0.693193	0.693113	0.693225	0.692218	0.694431	0.695120	0.696940	0.223560
36	Library	MOTORS WH/HR/SQFT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.024646	0.024660	[illegible]

P R O F I L E

No.	Name	Subprofiles & Total	2100	2200	2300	2400	SUM (WH/SF/DY)	WKEND 100	200	300	400	500
18	Telephone Exchange	TOTAL WH/HR/SQFT	2.110572	2.122725	2.110674	2.114623	[illegible]	1.937777	1.926633	1.919489	1.923539	1.927590
19.4	Fire Station	LIGHTING WH/HR/SQFT	0.411029	0.285759	0.342197	0.314002	[illegible]	0.363480	0.292510	0.332104	0.160679	0.179600
19.4	Fire Station	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
19.4	Fire Station	MISSION WH/HR/SQFT	0.002003	0.002003	0.002003	0.002003	2.0324367	0.002003	0.002003	0.002003	0.002003	0.002003
19.4	Fire Station	SUPPORT WH/HR/SQFT	0.854706	0.916459	0.881455	0.608187	18.065744	0.274711	0.274711	0.217480	0.401526	0.376967
19.4	Fire Station	TOTAL WH/HR/SQFT	1.267738	1.204221	1.225656	0.925072	28.670790	0.640195	0.569225	0.551588	0.564209	0.558570
20.1	Service Station	LIGHTING WH/HR/SQFT	0.457516	0.457516	0.457516	0.457516	9.8133986	0.457516	0.457516	0.457516	0.457516	0.457516
20.1	Service Station	MOTORS WH/HR/SQFT	0.224754	0.133333	0.133333	0.133333	11.054901	0.060947	0.060947	0.060947	0.060947	0.060947
20.1	Service Station	MISSION WH/HR/SQFT	0	0	0	0	0.1572712	0	0	0	0	0
20.1	Service Station	SUPPORT WH/HR/SQFT	0	0	0	0	0.675	0	0	0	0	0
20.1	Service Station	TOTAL WH/HR/SQFT	0.682271	0.590849	0.590849	0.590849	21.700571	0.518464	0.518464	0.518464	0.518464	0.518464
21	Training Aids Center	LIGHTING WH/HR/SQFT	0.047726	0.045688	0.046385	0.045420	1.6556551	0.045617	0.045813	0.045617	0.045322	0.045322
21	Training Aids Center	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
21	Training Aids Center	MISSION WH/HR/SQFT	0.001062	0.001016	0.001032	0.001010	0.2002342	0.001015	0.001019	0.001015	0.001008	0.001008
21	Training Aids Center	SUPPORT WH/HR/SQFT	0.029687	0.028419	0.028853	0.028253	0.8223311	0.028375	0.028497	0.028375	0.028192	0.028192
21	Training Aids Center	TOTAL WH/HR/SQFT	0.078476	0.075125	0.076271	0.074684	2.6782206	0.075008	0.075331	0.075008	0.074523	0.074523
22.1	POL Pump Station	LIGHTING WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
22.1	POL Pump Station	MOTORS WH/HR/SQFT	0	0	0	0	104.16280	0	0	0	0	0
22.1	POL Pump Station	MISSION WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
22.1	POL Pump Station	SUPPORT WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
22.1	POL Pump Station	TOTAL WH/HR/SQFT	0	0	0	0	104.16280	0	0	0	0	0
23	Fac Engr Maint Shop	LIGHTING WH/HR/SQFT	0.021874	0.021874	0.021874	0.021874	2.5449015	0.015801	0.015801	0.015801	0.015801	0.015801
23	Fac Engr Maint Shop	MOTORS WH/HR/SQFT	0.151435	0.151435	0.151435	0.151435	4.7727796	0.124930	0.124930	0.124930	0.124930	0.124930
23	Fac Engr Maint Shop	MISSION WH/HR/SQFT	0.036884	0.036884	0.036884	0.036884	5.0098777	0.030429	0.030429	0.030429	0.030429	0.030429
23	Fac Engr Maint Shop	SUPPORT WH/HR/SQFT	0.039281	[illegible]	0.042766	0.040420	2.7669259	0.031409	0.114211	0.021672	0.023608	0.113215
23	Fac Engr Maint Shop	TOTAL WH/HR/SQFT	0.249475	[illegible]	0.252961	0.250614	15.094484	0.202570	0.285372	0.192833	0.194769	0.284376
24	Chapel	LIGHTING WH/HR/SQFT	0.026043	[illegible]	0.026043	0.026043	1.4732896	0.026043	0.026043	0.026043	0.026043	0.026043
24	Chapel	MOTORS WH/HR/SQFT	0	[illegible]	0	0	0	0	0	0	0	0
24	Chapel	MISSION WH/HR/SQFT	0.000937	[illegible]	0.000937	0.000937	0.2444934	0.000937	0.000937	0.000937	0.000937	0.000937
24	Chapel	SUPPORT WH/HR/SQFT	0.131740	[illegible]	0.131740	0.131740	3.9310695	0.114159	0.101735	0.089311	0.142406	0.101735
24	Chapel	TOTAL WH/HR/SQFT	0.158721	[illegible]	0.158721	0.158721	5.6488526	0.141140	0.128716	0.116292	0.169387	0.128716
25	Laundry	LIGHTING WH/HR/SQFT	0.411880	[illegible]	0.235795	0.176474	8.1661946	0.176288	0.178619	0.178389	0.181195	0.179624
25	Laundry	MOTORS WH/HR/SQFT	0.165231	0.142592	0.119005	0.084062	3.3738452	0.084061	0.083529	0.083522	0.083533	0.109915
25	Laundry	MISSION WH/HR/SQFT	2.270827	1.763545	[illegible]	0.672350	36.096912	0.704955	0.716861	0.716637	0.731760	0.689431
25	Laundry	SUPPORT WH/HR/SQFT	0.456742	0.457481	[illegible]	0.395416	11.073570	0.397698	0.390343	0.387533	0.386405	0.388217
25	Laundry	TOTAL WH/HR/SQFT	3.304681	2.693801	[illegible]	1.328303	58.710522	1.363004	1.369347	1.366083	1.382894	1.367189
26	Bank	LIGHTING WH/HR/SQFT	0.002124	0.000771	0.000734	0.000756	2.6555458	0.003648	0.002714	0.004104	0.002736	0.002895
26	Bank	MOTORS WH/HR/SQFT	0.005949	0.002160	0.002057	0.002117	0.1425360	0.000224	0.000166	0.000252	0.000168	0.000178
26	Bank	MISSION WH/HR/SQFT	0	0	[illegible]	0	0.7783550	0	0	0	0	0
26	Bank	SUPPORT WH/HR/SQFT	0.004781	0.001736	0.001653	0.001701	1.1575572	0.001356	0.003002	0.001525	0.001017	0.003202
26	Bank	TOTAL WH/HR/SQFT	0.012855	0.004669	0.004445	0.004575	4.7339941	0.005229	0.005883	0.005883	0.003922	0.006275
27	Bowling Center	LIGHTING WH/HR/SQFT	1.468060	1.221325	1.072203	0.575306	19.364934	0.277141	0.277141	0.277141	0.277141	0.277141
27	Bowling Center	MOTORS WH/HR/SQFT	0.301496	0.301496	0.301496	0.250307	6.2102935	0.181815	0.158072	0.158072	0.158072	0.158072
27	Bowling Center	MISSION WH/HR/SQFT	1.814772	1.330575	1.330575	0.190910	15.188462	0.000321	0.000321	0.000321	0.000321	0.000321
27	Bowling Center	SUPPORT WH/HR/SQFT	1.875851	2.143498	1.703407	1.109635	36.911793	0.369824	0.749565	0.350096	0.301045	0.682981
27	Bowling Center	TOTAL WH/HR/SQFT	5.460180	4.996897	4.407683	2.126239	77.675484	0.829103	1.185101	0.785632	0.736581	1.118517
28	Lunch Room	LIGHTING WH/HR/SQFT	0.248506	0.122101	0.005865	0.005865	3.7145058	0.001376	0.001376	0.001376	0.001376	0.001376
28	Lunch Room	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
28	Lunch Room	MISSION WH/HR/SQFT	0.585416	0.291021	0.282061	0.281322	18.031767	0.125153	0.130437	0.132089	0.127927	0.128390
28	Lunch Room	SUPPORT WH/HR/SQFT	0.003888	0.000084	0.000084	0.000084	0.0714306	0.000039	0.000039	0.000039	0.000039	0.000039
28	Lunch Room	TOTAL WH/HR/SQFT	0.837810	0.413207	0.288010	0.287272	21.817703	0.126569	0.131854	0.133506	0.129344	0.129806
29	Child Support Service Ctr	LIGHTING WH/HR/SQFT	0.247957	0.247957	0.247957	0.247957	12.170035	0.228351	0.228351	0.228351	0.228351	0.228351
29	Child Support Service Ctr	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
29	Child Support Service Ctr	MISSION WH/HR/SQFT	0	0	0	0	0.3558711	0	0	0	0	0
29	Child Support Service Ctr	SUPPORT WH/HR/SQFT	0.142571	0.142571	0.142571	0.142571	10.231207	0.142571	0.142571	0.142571	0.142571	0.142571
29	Child Support Service Ctr	TOTAL WH/HR/SQFT	0.390528	0.390528	0.390528	0.390528	22.757114	0.370922	0.370922	0.370922	0.370922	0.370922
30	Exchange Retail/Sales	LIGHTING WH/HR/SQFT	0.077222	0.075582	0.087089	0.080940	10.383403	0.096720	0.097948	0.097875	0.098604	0.097788
30	Exchange Retail/Sales	MOTORS WH/HR/SQFT	0.000438	0.000435	0.000436	0.000462	0.0138264	0.000458	0.000446	0.000455	0.000448	0.000456
30	Exchange Retail/Sales	MISSION WH/HR/SQFT	0.243375	0.240718	0.240616	0.232034	6.4400065	0.269044	0.273325	0.272328	0.274758	0.272031
30	Exchange Retail/Sales	SUPPORT WH/HR/SQFT	0.146313	0.146221	0.149803	0.144487	4.2030454	0.136940	0.130183	0.131782	0.127654	0.130304
30	Exchange Retail/Sales	TOTAL WH/HR/SQFT	0.467350	0.462958	0.477945	0.457925	29.040281	0.503165	0.501902	0.502442	0.501465	0.500580
31	Exchange Branch	LIGHTING WH/HR/SQFT	0.129048	0.129048	0.129048	0.129048	10.914661	0.177005	0.177005	0.177005	0.177005	0.177005
31	Exchange Branch	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
31	Exchange Branch	MISSION WH/HR/SQFT	0.000316	0.000316	0.000316	0.000316	5.1762919	0.000454	0.000454	0.000454	0.000454	0.000454
31	Exchange Branch	SUPPORT WH/HR/SQFT	0.129561	0.083482	0.077272	0.067677	4.1218498	0.103722	0.099118	0.092999	0.089970	0.093378
31	Exchange Branch	TOTAL WH/HR/SQFT	0.258927	0.212847	0.206638	0.197043	20.212803	0.281182	0.276578	0.270459	0.267430	0.270838
32	Arts/Crafts/Skill Dev Ctr	LIGHTING WH/HR/SQFT	0.043011	0.010878	0.011724	0.012340	0.7714657	0.012200	0.013901	0.017185	0.015910	0.014534
32	Arts/Crafts/Skill Dev Ctr	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
32	Arts/Crafts/Skill Dev Ctr	MISSION WH/HR/SQFT	0.045397	0.002185	0.002406	0.002557	0.9220491	0.003593	0.004160	0.005203	0.004804	0.004365
32	Arts/Crafts/Skill Dev Ctr	SUPPORT WH/HR/SQFT	0.004270	0.012332	0.011564	0.010970	0.3294369	0.011842	0.009140	0.005716	0.007616	0.009045
32	Arts/Crafts/Skill Dev Ctr	TOTAL WH/HR/SQFT	0.092678	0.025396	0.025695	0.025868	2.0229518	0.027635	0.027201	0.028105	0.028331	0.027945
33	Club/Youth/Scout Bldg	LIGHTING WH/HR/SQFT	0.187342	0.132681	0.064254	0.064140	4.2468064	0.043640	0.043637	0.043666	0.043715	0.043631
33	Club/Youth/Scout Bldg	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
33	Club/Youth/Scout Bldg	MISSION WH/HR/SQFT	0.000708	0.000708	0.000380	0.000222	0.0391127	0.000222	0.000222	0.000222	0.000222	0.000222
33	Club/Youth/Scout Bldg	SUPPORT WH/HR/SQFT	0.138383	0.142654	0.180636	0.147238	5.6153903	0.170993	0.165857	0.171900	0.181042	0.172453
33	Club/Youth/Scout Bldg	TOTAL WH/HR/SQFT	0.326435	0.276044	0.245271	0.211601	9.9013095	0.214857	0.209716	0.215789	0.224981	0.216307
34	Community Center	LIGHTING WH/HR/SQFT	0.032763	0.032763	0.032763	0.032763	1.5302928	0.032763	0.032763	0.032763	0.032763	0.032763
34	Community Center	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
34	Community Center	MISSION WH/HR/SQFT	0	0	0	0	1.1219389	0	0	0	0	0
34	Community Center	SUPPORT WH/HR/SQFT	0.151407	0.227111	0.201876	0.176642	4.5824808	0.176228	0.117485	0.058742	0.088114	0.117485
34	Community Center	TOTAL WH/HR/SQFT	0.184171	0.259875	0.234640	0.209405	7.2347127	0.208992	0.150249	0.091506	0.120877	0.150249
35	Gymnasium/ Rec Bldg	LIGHTING WH/HR/SQFT	0.651849	0.179967	0.094127	0.093288	10.995129	0.100728	0.101003	0.100510	0.101462	0.101148
35	Gymnasium/ Rec Bldg	MOTORS WH/HR/SQFT	1.237905	1.116970	0.619289	0.369277	24.236281	0.389244	0.390850	0.387481	0.395546	0.409518
35	Gymnasium/ Rec Bldg	MISSION WH/HR/SQFT	0.174196	0.000208	0.000208	0.000208	3.4566981	0.000236	0.000236	0.000236	0.000236	0.000236
35	Gymnasium/ Rec Bldg	SUPPORT WH/HR/SQFT	0.089479	0.034041	0.015818	0.010634	1.9505006	0.011280	0.010897	0.016108	0.010506	0.010500
35	Gymnasium/ Rec Bldg	TOTAL WH/HR/SQFT	2.153430	1.431188	0.729444	0.473409	40.638609	0.501489	0.502986	0.504417	0.507751	0.521404
36	Library	LIGHTING WH/HR/SQFT	0.072608	0.068425	0.071228	0.071684	7.4261384	0.069512	0.073311	0.074170	0.070606	0.074170
36	Library	MOTORS WH/HR/SQFT	0.018589	0.014961	0.014990	0.015005	0.4602441	0.014177	0.015018	0.015022	0.014990	0.015022

Facility #	Name	Subprofiles & Total	600	700	800	900	1000	1100	1200	1300	1400	1500
17	Telephone Exchange	TOTAL WH/HR/SQFT	1.942684	1.[illegible]	2.200521	2.410525	2.342601	2.[illegible]	2.406446	2.410423	2.274728	2.[illegible]
19.4	Fire Station	LIGHTING WH/HR/SQFT	0.165190	0.150675	0.549206	0.416441	0.404604	0.421605	0.422546	0.424416	0.220521	0.[illegible]
19.4	Fire Station	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
19.4	Fire Station	MISSION WH/HR/SQFT	0.002003	0.002003	0.214475	0.214475	0.214475	0.214475	0.214475	0.214475	0.214475	0.214475
19.4	Fire Station	SUPPORT WH/HR/SQFT	0.404079	0.558534	1.398301	0.[illegible]	0.[illegible]	0.493621	0.[illegible]	0.[illegible]	0.552547	0.[illegible]
19.4	Fire Station	TOTAL WH/HR/SQFT	0.571281	0.719213	2.152[illegible]	1.[illegible]	1.[illegible]	1.129[illegible]	1.512[illegible]	1.[illegible]	0.987544	0.[illegible]
20.1	Service Station	LIGHTING WH/HR/SQFT	0.452516	0.400326	0.142983	0.[illegible]	0.121560	0.160764	0.160764	0.160764	0.142403	0.160764
20.1	Service Station	MOTORS WH/HR/SQFT	0.060947	0.060947	0.103496	0.[illegible]	1.161029	1.101[illegible]	1.101[illegible]	1.101[illegible]	0.794934	1.14[illegible]
20.1	Service Station	MISSION WH/HR/SQFT	0	0	0	0.010[illegible]	0.010[illegible]	0.010[illegible]	0.010[illegible]	0.010[illegible]	0.014297	0.010[illegible]
20.1	Service Station	SUPPORT WH/HR/SQFT	0	0	0.049591	0.051[illegible]	0.051829	0.053594	0.[illegible]	0.102614	0.053594	0.[illegible]
20.1	Service Station	TOTAL WH/HR/SQFT	0.510464	0.461274	0.295521	0.[illegible]	1.352859	1.334150	1.401209	1.[illegible]	1.005310	1.[illegible]
21	Training Aids Center	LIGHTING WH/HR/SQFT	0.044907	0.043920	0.037920	0.020164	0.007841	0.003312	0.002041	0.002021	0.002210	0.002146
21	Training Aids Center	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
21	Training Aids Center	MISSION WH/HR/SQFT	0.000999	0.000977	0.001490	0.001032	0.000695	0.000502	0.000[illegible]	0.000427	0.000440	0.000[illegible]
21	Training Aids Center	SUPPORT WH/HR/SQFT	0.026616	0.028655	0.032955	0.025[illegible]	0.026704	0.024308	0.02[illegible]	0.02[illegible]	0.023051	0.02[illegible]
21	Training Aids Center	TOTAL WH/HR/SQFT	0.074523	0.073553	0.071774	0.049289	0.035240	0.028128	0.027158	0.025218	0.025703	0.025541
22.1	POL Pump Station	LIGHTING WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
22.1	POL Pump Station	MOTORS WH/HR/SQFT	0	0	2.556558	2.556558	2.556558	2.556558	2.556558	2.556558	2.556558	2.556558
22.1	POL Pump Station	MISSION WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
22.1	POL Pump Station	SUPPORT WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
22.1	POL Pump Station	TOTAL WH/HR/SQFT	0	0	2.556558	2.556558	2.556558	2.556558	2.556558	2.556558	2.556558	2.556558
23	Fac Engr Maint Shop	LIGHTING WH/HR/SQFT	0.015801	0.015801	0.015801	0.015801	0.015801	0.015801	0.015801	0.015801	0.015801	0.015801
23	Fac Engr Maint Shop	MOTORS WH/HR/SQFT	0.124930	0.124930	0.101186	0.101186	0.101186	0.101186	0.101186	0.101186	0.101186	0.101186
23	Fac Engr Maint Shop	MISSION WH/HR/SQFT	0.030429	0.030429	0.030429	0.030429	0.030429	0.030429	0.030429	0.030429	0.030429	0.030429
23	Fac Engr Maint Shop	SUPPORT WH/HR/SQFT	0.020476	0.031409	0.027532	0.[illegible]	0.027574	0.033[illegible]	0.122012	0.[illegible]	0.119080	0.03[illegible]
23	Fac Engr Maint Shop	TOTAL WH/HR/SQFT	0.1[illegible]	0.202570	0.174954	0.32[illegible]	0.224990	0.180[illegible]	0.26[illegible]	0.2[illegible]	0.266497	0.1[illegible]
24	Chapel	LIGHTING WH/HR/SQFT	0.026043	0.071669	0.06[illegible]	0.183197	0.305[illegible]	0.305[illegible]	0.16[illegible]	0.0[illegible]	0.083978	0.050680
24	Chapel	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
24	Chapel	MISSION WH/HR/SQFT	0.000937	0.000937	0.029676	0.074801	0.053118	0.074801	0.051[illegible]	0.027918	0.027918	0.025281
24	Chapel	SUPPORT WH/HR/SQFT	0.107947	0.161042	0.115521	0.206055	0.146740	0.159524	0.200195	0.140[illegible]	0.140868	0.176050
24	Chapel	TOTAL WH/HR/SQFT	0.134928	0.193649	0.214576	0.464054	0.505196	0.539[illegible]	0.434753	0.252785	0.252785	0.252012
25	Laundry	LIGHTING WH/HR/SQFT	0.170959	0.107556	0.283710	0.421637	0.439995	0.453162	0.460400	0.466559	0.466357	0.466724
25	Laundry	MOTORS WH/HR/SQFT	0.116532	0.142376	0.164699	0.165025	0.165632	0.165701	0.166[illegible]	0.166629	0.166665	0.167103
25	Laundry	MISSION WH/HR/SQFT	0.691195	0.640216	0.972924	1.522172	1.840013	1.967421	2.557[illegible]	2.626660	2.734252	2.741604
25	Laundry	SUPPORT WH/HR/SQFT	0.385165	0.398622	0.441980	0.483314	0.496042	0.510702	0.5[illegible]	0.533947	0.530146	0.530462
25	Laundry	TOTAL WH/HR/SQFT	1.371853	1.373772	1.863313	2.592201	2.[illegible]	3.[illegible]	3.[illegible]	3.613804	3.920423	3.926[illegible]
26	Bank	LIGHTING WH/HR/SQFT	0.003578	0.001936	0.001627	0.000[illegible]	0.003255	0.00152[illegible]	0.001[illegible]	0.00115[illegible]	0.000866	0.001[illegible]
26	Bank	MOTORS WH/HR/SQFT	0.000220	0.000119	0.000206	0.000082	0.000412	0.000193	0.000210	0.000145	0.000109	0.000206
26	Bank	MISSION WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
26	Bank	SUPPORT WH/HR/SQFT	0.001431	0.001540	0.001434	0.001[illegible]	0.002[illegible]	0.002[illegible]	0.001[illegible]	0.000989	0.002073	0.001434
26	Bank	TOTAL WH/HR/SQFT	0.005229	0.003595	0.004268	0.00[illegible]	0.00[illegible]	0.004[illegible]	0.00[illegible]	0.002[illegible]	0.003050	0.00[illegible]
27	Bowling Center	LIGHTING WH/HR/SQFT	0.272141	0.170547	0.186[illegible]	0.2[illegible]	0.448[illegible]	0.710[illegible]	1.15[illegible]	1.150[illegible]	1.150982	1.15[illegible]
27	Bowling Center	MOTORS WH/HR/SQFT	0.158072	0.158072	0.158072	0.158072	0.189461	0.215[illegible]	0.264[illegible]	0.264392	0.264392	0.264392
27	Bowling Center	MISSION WH/HR/SQFT	0.000321	0.000321	0.035735	0.035735	0.035735	0.226[illegible]	0.52[illegible]	1.013143	1.368564	1.461927
27	Bowling Center	SUPPORT WH/HR/SQFT	0.352291	0.305436	0.350[illegible]	0.717[illegible]	0.489792	0.85[illegible]	2.1[illegible]	2.236198	2.431016	1.776513
27	Bowling Center	TOTAL WH/HR/SQFT	0.787827	0.642378	0.741832	1.210220	1.163643	2.00[illegible]	4.151[illegible]	4.672716	5.222956	4.6[illegible]
28	Lunch Room	LIGHTING WH/HR/SQFT	0.001376	0.001376	0.001376	0.001376	0.001376	0.001376	0.001376	0.001376	0.001376	0.001376
28	Lunch Room	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
28	Lunch Room	MISSION WH/HR/SQFT	0.197735	0.393986	0.303945	0.[illegible]	0.507421	0.531700	0.5[illegible]	0.523179	0.503780	0.40[illegible]
28	Lunch Room	SUPPORT WH/HR/SQFT	0.000039	0.000039	0.000039	0.000039	0.000039	0.000039	0.000039	0.000039	0.000039	0.000039
28	Lunch Room	TOTAL WH/HR/SQFT	0.199152	0.395402	0.305362	0.300440	0.508638	0.53[illegible]	0.507450	0.524594	0.505196	0.40[illegible]
29	Child Support Service Ctr	LIGHTING WH/HR/SQFT	0.220351	0.201458	0.172048	0.172048	0.172048	0.172048	0.172048	0.172048	0.172048	0.11[illegible]
29	Child Support Service Ctr	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
29	Child Support Service Ctr	MISSION WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
29	Child Support Service Ctr	SUPPORT WH/HR/SQFT	0.142571	0.142571	0.171642	0.346245	0.346245	0.171642	0.346245	0.346245	0.171642	0.171642
29	Child Support Service Ctr	TOTAL WH/HR/SQFT	0.370922	0.344029	0.343691	0.518294	0.518294	0.343691	0.518294	0.518294	0.343691	0.29[illegible]
30	Exchange Retail/Sales	LIGHTING WH/HR/SQFT	0.095077	0.094192	0.554005	1.019110	1.166107	1.2[illegible]	1.3[illegible]	1.352021	1.451491	1.[illegible]
30	Exchange Retail/Sales	MOTORS WH/HR/SQFT	0.000442	0.000427	0.000040	0.000[illegible]	0.000020	0.000[illegible]	0.000[illegible]	0.000[illegible]	0.000082	0.000[illegible]
30	Exchange Retail/Sales	MISSION WH/HR/SQFT	0.266170	0.266140	0.181871	0.243164	0.230[illegible]	0.25[illegible]	0.25[illegible]	0.254240	0.248178	0.24[illegible]
30	Exchange Retail/Sales	SUPPORT WH/HR/SQFT	0.134393	0.134764	0.130820	0.161984	0.148[illegible]	0.15[illegible]	0.167150	0.162[illegible]	0.160926	0.1[illegible]
30	Exchange Retail/Sales	TOTAL WH/HR/SQFT	0.501083	0.495533	0.86[illegible]	1.425[illegible]	1.553[illegible]	1.684[illegible]	1.75[illegible]	1.768552	1.761479	1.7[illegible]
31	Exchange Branch	LIGHTING WH/HR/SQFT	0.177005	0.177005	0.177005	0.177005	0.312[illegible]	0.7[illegible]	1.182550	1.182550	1.182550	1.1[illegible]
31	Exchange Branch	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
31	Exchange Branch	MISSION WH/HR/SQFT	0.000454	0.000454	0.000454	0.000454	0.005431	0.33[illegible]	0.66[illegible]	0.66[illegible]	0.666580	0.66[illegible]
31	Exchange Branch	SUPPORT WH/HR/SQFT	0.099497	0.102208	0.114006	0.375203	0.545243	0.490646	0.411409	0.419137	0.397770	0.41[illegible]
31	Exchange Branch	TOTAL WH/HR/SQFT	0.276957	0.279668	0.291466	0.552743	0.863031	1.597[illegible]	2.2[illegible]	2.268284	2.246917	2.2[illegible]
32	Arts/Crafts/Skill Dev Ctr	LIGHTING WH/HR/SQFT	0.013077	0.012200	0.000614	0.01[illegible]	0.024446	0.016605	0.00[illegible]	0.007051	0.009764	0.00[illegible]
32	Arts/Crafts/Skill Dev Ctr	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
32	Arts/Crafts/Skill Dev Ctr	MISSION WH/HR/SQFT	0.003888	0.003593	0.000667	0.012415	0.027069	0.032219	0.021350	0.025233	0.034943	0.024127
32	Arts/Crafts/Skill Dev Ctr	SUPPORT WH/HR/SQFT	0.010435	0.011042	0.010487	0.015059	0.013270	0.004163	0.010[illegible]	0.006409	0.001725	0.001191
32	Arts/Crafts/Skill Dev Ctr	TOTAL WH/HR/SQFT	0.027401	0.026835	0.028[illegible]	0.040202	0.064706	0.053067	0.0[illegible]	0.038694	0.046434	0.03[illegible]
33	Club/Youth/Scout Bldg	LIGHTING WH/HR/SQFT	0.043690	0.117600	0.112419	0.057094	0.051738	0.056203	0.050073	0.090488	0.203427	0.251311
33	Club/Youth/Scout Bldg	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
33	Club/Youth/Scout Bldg	MISSION WH/HR/SQFT	0.000222	0.000222	0.000222	0.000222	0.000222	0.000222	0.000222	0.000222	0.001599	0.001599
33	Club/Youth/Scout Bldg	SUPPORT WH/HR/SQFT	0.165707	0.153498	0.145136	0.12[illegible]	0.125157	0.138117	0.124[illegible]	0.135743	0.209442	0.20[illegible]
33	Club/Youth/Scout Bldg	TOTAL WH/HR/SQFT	0.209620	0.271[illegible]	0.257[illegible]	0.181[illegible]	0.177118	0.194543	0.18[illegible]	0.226454	0.414469	0.45[illegible]
34	Community Center	LIGHTING WH/HR/SQFT	0.032763	0.03[illegible]	0.07115[illegible]	0.1201[illegible]	0.120133	0.1201[illegible]	0.1201[illegible]	0.120133	0.120133	0.120133
34	Community Center	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
34	Community Center	MISSION WH/HR/SQFT	0	0	0.063875	0.083875	0.083875	0.083875	0.083875	0.083875	0.083875	0.083875
34	Community Center	SUPPORT WH/HR/SQFT	0.146057	0.12[illegible]	0.121020	0.24[illegible]	0.235205	0.33[illegible]	0.324924	0.266232	0.245547	0.245547
34	Community Center	TOTAL WH/HR/SQFT	0.17[illegible]	0.[illegible]	0.25[illegible]	0.440247	0.439214	0.53[illegible]	0.52[illegible]	0.470240	0.449556	0.44[illegible]
35	Gymnasium/Rec Bldg	LIGHTING WH/HR/SQFT	0.[illegible]	0.[illegible]	0.400[illegible]	0.44[illegible]	0.[illegible]	0.201[illegible]	0.2[illegible]	0.25[illegible]	0.255424	0.2[illegible]
35	Gymnasium/Rec Bldg	MOTORS WH/HR/SQFT	0.907342	1.20[illegible]	1.23[illegible]	1.29[illegible]	1.39[illegible]	1.422000	1.38[illegible]	1.381019	1.384164	1.392434
35	Gymnasium/Rec Bldg	MISSION WH/HR/SQFT	0.000216	0.140[illegible]	0.144023	0.146653	0.146661	0.269124	0.304528	0.292407	0.303131	0.303093
35	Gymnasium/Rec Bldg	SUPPORT WH/HR/SQFT	0.015994	0.011422	0.025252	0.040441	0.040319	0.101624	0.11[illegible]	0.140526	0.131392	0.135220
35	Gymnasium/Rec Bldg	TOTAL WH/HR/SQFT	1.102696	1.251[illegible]	1.809263	1.924955	2.214545	2.494529	2.577661	2.567842	2.574062	2.605560
36	Library	LIGHTING WH/HR/SQFT	0.022810	0.06[illegible]	0.0[illegible]	0.054[illegible]	0.044905	0.104[illegible]	0.301[illegible]	0.298348	0.297916	0.[illegible]
36	Library	MOTORS WH/HR/SQFT	0.015011	0.014[illegible]	0.01[illegible]	0.01[illegible]	0.01[illegible]	0.01[illegible]	0.01[illegible]	0.018364	0.018361	0.01[illegible]

P R O F I L E No. Name	Subprofiles & Total	1600	1700	1800	1900	2000	2100	2200	2300	2400	SUM (WH/SF/DY)
18 Telephone Exchange	TOTAL WH/HR/SQFT	2.262509	2.154394	2.403796	2.319761	2.111404	2.127302	2.115200	2.111404	2.123362	52.07670
19.4 Fire Station	LIGHTING WH/HR/SQFT	0.179248	[illegible]	[illegible]	[illegible]	0.200117	[illegible]	0.167465	[illegible]	0.419363	9.041972
19.4 Fire Station	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
19.4 Fire Station	MISSION WH/HR/SQFT	0.214475	0.173667	[illegible]	[illegible]	0.002003	[illegible]	[illegible]	[illegible]	0.002003	2.303714
19.4 Fire Station	SUPPORT WH/HR/SQFT	[illegible]	[illegible]	[illegible]	[illegible]	0.599212	[illegible]	[illegible]	[illegible]	0.276440	14.52145
19.4 Fire Station	TOTAL WH/HR/SQFT	1.032002	1.062844	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.045042	0.697607	25.86715
20.1 Service Station	LIGHTING WH/HR/SQFT	[illegible]	0.225816	0.457516	0.457516	0.457516	0.457516	0.457516	0.457516	0.457516	7.942712
20.1 Service Station	MOTORS WH/HR/SQFT	1.140606	0.183496	0.060947	0.060947	0.060947	0.060947	0.060947	0.060947	0.060947	9.495506
20.1 Service Station	MISSION WH/HR/SQFT	0.018082	0	0	0	0	0	0	0	0	0.142473
20.1 Service Station	SUPPORT WH/HR/SQFT	0.053594	0.001143	0	0	0	0	0	0	0	0.671568
20.1 Service Station	TOTAL WH/HR/SQFT	1.430637	0.460457	0.518464	0.518464	0.518464	0.518464	0.518464	0.518464	0.518464	18.25776
21 Training Aids Center	LIGHTING WH/HR/SQFT	0.007015	0.026171	0.044240	0.044339	0.045027	0.045322	0.045420	0.045027	0.044634	0.741779
21 Training Aids Center	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
21 Training Aids Center	MISSION WH/HR/SQFT	0.000668	0.000732	0.000984	0.000986	0.001002	0.001008	0.001010	0.001002	0.000993	0.020953
21 Training Aids Center	SUPPORT WH/HR/SQFT	0.025777	0.027412	0.027519	0.027580	0.028008	0.028192	0.028253	0.028008	0.027763	0.652398
21 Training Aids Center	TOTAL WH/HR/SQFT	0.033462	0.054316	0.072744	0.072906	0.074038	0.074523	0.074684	0.074038	0.073391	1.415130
22.1 POL Pump Station	LIGHTING WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
22.1 POL Pump Station	MOTORS WH/HR/SQFT	2.556558	0	0	0	0	0	0	0	0	23.00902
22.1 POL Pump Station	MISSION WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
22.1 POL Pump Station	SUPPORT WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
22.1 POL Pump Station	TOTAL WH/HR/SQFT	2.556558	0	0	0	0	0	0	0	0	23.00902
23 Fac Engr Maint Shop	LIGHTING WH/HR/SQFT	0.015801	0.015801	0.015801	0.015801	0.015801	0.015801	0.015801	0.015801	0.015801	0.379228
23 Fac Engr Maint Shop	MOTORS WH/HR/SQFT	0.101186	0.124930	0.124930	0.124930	0.124930	0.124930	0.124930	0.124930	0.124930	2.784643
23 Fac Engr Maint Shop	MISSION WH/HR/SQFT	0.030429	0.030429	0.030429	0.030429	0.030429	0.030429	0.030429	0.030429	0.030429	0.730297
23 Fac Engr Maint Shop	SUPPORT WH/HR/SQFT	0.032349	0.032349	0.238307	0.121016	0.034342	0.030412	0.115208	0.033345	0.031409	1.715616
23 Fac Engr Maint Shop	TOTAL WH/HR/SQFT	0.179766	0.203510	0.410068	0.292177	0.205503	0.201574	0.286369	0.204506	0.202570	5.609786
24 Chapel	LIGHTING WH/HR/SQFT	0.039404	0.032724	0.031669	0.031669	0.026043	0.026043	0.026043	0.026043	0.026043	1.718634
24 Chapel	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
24 Chapel	MISSION WH/HR/SQFT	0.024402	0.000937	0.000937	0.000937	0.000937	0.000937	0.000937	0.000937	0.000937	0.403343
24 Chapel	SUPPORT WH/HR/SQFT	0.141591	0.173700	0.132795	0.139007	0.126583	0.114159	0.148618	0.126583	0.114159	3.321455
24 Chapel	TOTAL WH/HR/SQFT	0.205399	0.207362	0.165402	0.171614	0.153564	0.141140	0.175599	0.153564	0.141140	5.443438
25 Laundry	LIGHTING WH/HR/SQFT	0.494831	0.491023	0.489251	0.486937	0.478760	0.414164	0.320669	0.239507	0.171728	8.397065
25 Laundry	MOTORS WH/HR/SQFT	0.167225	0.166687	0.166187	0.165723	0.165277	0.165249	0.142580	0.119035	0.084024	3.378594
25 Laundry	MISSION WH/HR/SQFT	2.836933	2.759274	2.686375	2.684420	2.757247	2.268303	1.643479	0.910517	0.676365	41.08521
25 Laundry	SUPPORT WH/HR/SQFT	0.542156	0.536781	0.522990	0.482317	0.467387	0.458012	0.456643	0.422175	0.391892	11.07322
25 Laundry	TOTAL WH/HR/SQFT	4.041147	3.953767	3.864805	3.819398	3.868672	3.305735	2.571373	1.691236	1.324010	63.93410
26 Bank	LIGHTING WH/HR/SQFT	0.009860	0.028627	0.023672	0.037215	0.031013	0.003921	0.001960	0.002468	0.003192	0.175921
26 Bank	MOTORS WH/HR/SQFT	0.001247	0.002369	0.001455	0.002288	0.001907	0.000241	0.000120	0.000151	0.000196	0.012875
26 Bank	MISSION WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
26 Bank	SUPPORT WH/HR/SQFT	0.015910	0.014324	0.026164	0.013835	0.011529	0.002897	0.002168	0.001824	0.001186	0.117147
26 Bank	TOTAL WH/HR/SQFT	0.027018	0.045321	0.051313	0.053340	0.044450	0.007059	0.004248	0.004445	0.004575	0.305944
27 Bowling Center	LIGHTING WH/HR/SQFT	1.158982	1.158982	1.198419	1.257576	1.336451	1.336451	1.187320	1.038206	0.626124	18.42279
27 Bowling Center	MOTORS WH/HR/SQFT	0.264392	0.264392	0.264392	0.264392	0.264392	0.264392	0.264392	0.264392	0.207409	5.231034
27 Bowling Center	MISSION WH/HR/SQFT	1.817348	1.817348	1.333151	1.333151	1.817348	1.817348	2.172769	1.461927	0.190910	18.46966
27 Bowling Center	SUPPORT WH/HR/SQFT	1.982992	1.797233	2.352141	2.075711	1.885844	1.950798	2.301069	1.668457	0.862643	31.05279
27 Bowling Center	TOTAL WH/HR/SQFT	5.223716	5.037957	5.148105	4.930831	5.304037	5.368991	5.925560	4.432984	1.887087	73.17628
28 Lunch Room	LIGHTING WH/HR/SQFT	0.001376	0.001376	0.001376	0.001376	0.001376	0.001376	0.001376	0.001376	0.001376	0.033046
28 Lunch Room	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
28 Lunch Room	MISSION WH/HR/SQFT	0.433338	0.400432	0.322379	0.161915	0.130041	0.126243	0.127267	0.128092	0.128687	7.010782
28 Lunch Room	SUPPORT WH/HR/SQFT	0.000039	0.000039	0.000039	0.000039	0.000039	0.000039	0.000039	0.000039	0.000039	0.000951
28 Lunch Room	TOTAL WH/HR/SQFT	0.434755	0.401849	0.323795	0.163331	0.131458	0.127659	0.128683	0.129509	0.130103	7.044780
29 Child Support Service Ctr	LIGHTING WH/HR/SQFT	0.119765	0.146996	0.187842	0.228351	0.228351	0.228351	0.228351	0.228351	0.228351	4.720389
29 Child Support Service Ctr	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
29 Child Support Service Ctr	MISSION WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
29 Child Support Service Ctr	SUPPORT WH/HR/SQFT	0.171642	0.142571	0.142571	0.142571	0.142571	0.142571	0.142571	0.142571	0.142571	4.381760
29 Child Support Service Ctr	TOTAL WH/HR/SQFT	0.291408	0.289567	0.330413	0.370922	0.370922	0.370922	0.370922	0.370922	0.370922	9.102149
30 Exchange Retail/Sales	LIGHTING WH/HR/SQFT	1.299562	0.872788	0.718385	0.147825	0.086070	0.089238	0.089231	0.086194	0.095617	13.54265
30 Exchange Retail/Sales	MOTORS WH/HR/SQFT	0.000872	0.000455	0.000440	0.000441	0.000458	0.000481	0.000459	0.000458	0.000434	0.014782
30 Exchange Retail/Sales	MISSION WH/HR/SQFT	0.239464	0.254839	0.256682	0.320650	0.238429	0.245751	0.247835	0.238813	0.268573	6.125655
30 Exchange Retail/Sales	SUPPORT WH/HR/SQFT	0.160316	0.161604	0.150851	0.145651	0.146335	0.138509	0.133068	0.146370	0.135659	3.499632
30 Exchange Retail/Sales	TOTAL WH/HR/SQFT	1.700216	1.289687	1.126359	0.614569	0.471287	0.473980	0.470594	0.471836	0.500285	23.18313
31 Exchange Branch	LIGHTING WH/HR/SQFT	1.182550	0.662320	0.551084	0.312356	0.177005	0.177005	0.177005	0.177005	0.177005	10.98800
31 Exchange Branch	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
31 Exchange Branch	MISSION WH/HR/SQFT	0.666588	0.662612	0.510758	0.154046	0.000454	0.000454	0.000454	0.000454	0.000454	5.012002
31 Exchange Branch	SUPPORT WH/HR/SQFT	0.402992	0.414515	0.175864	0.110220	0.108326	0.099557	0.095710	0.099178	0.107509	5.467307
31 Exchange Branch	TOTAL WH/HR/SQFT	2.252139	1.739448	1.237707	0.576623	0.285787	0.277017	0.273171	0.276639	0.284969	21.46732
32 Arts/Crafts/Skill Dev Ctr	LIGHTING WH/HR/SQFT	0.007111	0.007957	0.002614	0.003298	0.010659	0.011652	0.012982	0.010971	0.012037	0.275050
32 Arts/Crafts/Skill Dev Ctr	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
32 Arts/Crafts/Skill Dev Ctr	MISSION WH/HR/SQFT	0.019589	0.019790	0.000695	0.000877	0.003048	0.003405	0.003856	0.003166	0.003537	0.279629
32 Arts/Crafts/Skill Dev Ctr	SUPPORT WH/HR/SQFT	0.001601	0.001659	0.023886	0.024126	0.013276	0.012075	0.009922	0.013420	0.012545	0.240716
32 Arts/Crafts/Skill Dev Ctr	TOTAL WH/HR/SQFT	0.028302	0.029406	0.027196	0.028302	0.026964	0.027132	0.026761	0.027559	0.028120	0.795397
33 Club/Youth/Scout Bldg	LIGHTING WH/HR/SQFT	0.248416	0.250206	0.256436	0.212844	0.211920	0.211639	0.112258	0.089190	0.089224	2.942396
33 Club/Youth/Scout Bldg	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
33 Club/Youth/Scout Bldg	MISSION WH/HR/SQFT	0.001599	0.001599	0.001599	0.001599	0.001599	0.001599	0.001599	0.000222	0.000222	0.017735
33 Club/Youth/Scout Bldg	SUPPORT WH/HR/SQFT	0.266488	0.255708	0.348400	0.292372	0.208447	[illegible]	0.194900	0.142266	0.182276	4.435614
33 Club/Youth/Scout Bldg	TOTAL WH/HR/SQFT	0.516504	0.507514	0.606436	0.506816	0.421967	[illegible]	[illegible]	0.231687	0.271722	7.395745
34 Community Center	LIGHTING WH/HR/SQFT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.032763	0.032763	1.474693
34 Community Center	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
34 Community Center	MISSION WH/HR/SQFT	[illegible]	0	0	0	0	0	0	0	0	[illegible]
34 Community Center	SUPPORT WH/HR/SQFT	0.238556	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.117485	[illegible]	0.176228	[illegible]
34 Community Center	TOTAL WH/HR/SQFT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.150249	[illegible]	0.208992	[illegible]
35 Gymnasium/ Rec Bldg	LIGHTING WH/HR/SQFT	[illegible]	[illegible]	0.744204	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.108710	10.45210
35 Gymnasium/ Rec Bldg	MOTORS WH/HR/SQFT	1.369270	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.196321	0.849061	0.401967	25.50522
35 Gymnasium/ Rec Bldg	MISSION WH/HR/SQFT	[illegible]	[illegible]	[illegible]	0.149155	[illegible]	[illegible]	[illegible]	[illegible]	0.000236	3.306156
35 Gymnasium/ Rec Bldg	SUPPORT WH/HR/SQFT	0.147563	0.145172	0.110111	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.012064	1.572079
35 Gymnasium/ Rec Bldg	TOTAL WH/HR/SQFT	2.572892	2.602761	2.450100	2.041645	[illegible]	[illegible]	1.402922	0.962994	0.594979	40.80056
[illegible]	LIGHTING WH/HR/SQFT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.068691	[illegible]
[illegible]	MOTORS WH/HR/SQFT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

No.	Name	Subprocesses & Total	WKDAY 100	200	300	400	500	600	700	800	900	1000
36	Library	MISSION WH/HR/SQFT	0	0	0	0	0	0	0	0.001865	0.002065	0.030048
36	Library	SUPPORT WH/HR/SQFT	0.052254	0.052251	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.054304	0.053807	0.053810
36	Library	TOTAL WH/HR/SQFT	[illegible]	0.138804	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.140419	0.251380	0.380476
37	Rec Center/EM Club	LIGHTING WH/HR/SQFT	0.180788	0.180252	[illegible]	0.175104	[illegible]	0.171762	[illegible]	0.202606	0.614333	0.730441
37	Rec Center/EM Club	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
37	Rec Center/EM Club	MISSION WH/HR/SQFT	0.000206	0.000206	[illegible]	[illegible]	0.000195	0.000196	[illegible]	0.000200	0.007646	0.014486
37	Rec Center/EM Club	SUPPORT WH/HR/SQFT	0.008891	0.008862	[illegible]	[illegible]	0.006214	[illegible]	[illegible]	0.020417	0.061187	[illegible]
37	Rec Center/EM Club	TOTAL WH/HR/SQFT	0.189647	0.189126	[illegible]	[illegible]	[illegible]	0.180210	[illegible]	0.231424	0.683167	0.815020
38	Theater	LIGHTING WH/HR/SQFT	0.194852	0.201252	[illegible]	[illegible]	0.162409	[illegible]	[illegible]	0.155022	0.144955	0.165455
38	Theater	MOTORS WH/HR/SQFT	0.314713	0.120012	[illegible]	0.100754	0.106242	0.106265	[illegible]	0.100715	0.115359	0.131674
38	Theater	MISSION WH/HR/SQFT	0.000210	0.000218	0.000202	0.000171	0.000180	0.000161	0.000172	0.000171	0.000196	0.000224
38	Theater	SUPPORT WH/HR/SQFT	0.012078	0.048617	[illegible]	0.022006	0.014539	0.025408	0.014822	0.013886	0.015931	0.014514
38	Theater	TOTAL WH/HR/SQFT	0.526859	0.368621	0.323024	0.281775	0.288372	0.290584	[illegible]	0.269755	0.276443	0.311868
39	Class VI Store	LIGHTING WH/HR/SQFT	0.069845	0.069845	0.069845	0.069845	0.069845	0.069845	0.069845	0.069845	0.069845	0.216265
39	Class VI Store	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
39	Class VI Store	MISSION WH/HR/SQFT	0.489000	0.591381	0.576021	0.554515	0.606942	0.520948	[illegible]	1.180660	1.452105	1.950698
39	Class VI Store	SUPPORT WH/HR/SQFT	0.092121	0.092121	0.092121	0.092121	0.092121	0.092121	0.092121	0.262590	0.272986	0.295525
39	Class VI Store	TOTAL WH/HR/SQFT	0.651087	0.753348	[illegible]	0.716482	0.768909	0.682914	0.755712	1.518096	1.794936	2.462489
40.4	Misc Sheds/Garages/Detached Bldgs	LIGHTING WH/HR/SQFT	0.003928	0.003928	0.003928	0.003928	0.003928	0.003928	[illegible]	0.056689	0.056689	0.056689
40.4	Misc Sheds/Garages/Detached Bldgs	MOTORS WH/HR/SQFT	0.003574	0.003574	0.003574	0.003574	0.003574	0.003574	[illegible]	0.005137	0.005587	0.005587
40.4	Misc Sheds/Garages/Detached Bldgs	MISSION WH/HR/SQFT	0.000264	0.000264	0.000264	0.000264	0.000264	0.000264	0.000264	0.015692	0.035671	0.035671
40.4	Misc Sheds/Garages/Detached Bldgs	SUPPORT WH/HR/SQFT	0.062387	0.063791	0.063791	0.094164	0.065194	0.063791	[illegible]	0.140175	0.151736	0.113797
40.4	Misc Sheds/Garages/Detached Bldgs	TOTAL WH/HR/SQFT	0.070155	0.071559	0.071559	0.101932	0.072962	0.071559	[illegible]	[illegible]	0.249683	0.217744
41	Post Office	LIGHTING WH/HR/SQFT	0.062845	0.057412	0.064093	[illegible]	0.065878	[illegible]	[illegible]	[illegible]	0.193304	0.214427
41	Post Office	MOTORS WH/HR/SQFT	0.004694	0.004469	0.004654	0.004736	0.005144	0.011263	[illegible]	0.009620	0.010797	0.012744
41	Post Office	MISSION WH/HR/SQFT	0.022776	0.021573	0.022459	[illegible]	0.024027	[illegible]	0.038842	0.132021	0.249938	0.169885
41	Post Office	SUPPORT WH/HR/SQFT	0.034561	[illegible]	0.050022	0.051006	[illegible]	0.044668	[illegible]	0.125890	0.156929	0.162610
41	Post Office	TOTAL WH/HR/SQFT	0.124078	[illegible]	[illegible]	0.124410	[illegible]	[illegible]	[illegible]	0.445209	0.610964	[illegible]
42.1	Sentry Station	LIGHTING WH/HR/SQFT	0.518517	0.518517	0.518517	0.518517	0.518517	0.518517	0.518517	0.103703	0.103703	0.103703
42.1	Sentry Station	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
42.1	Sentry Station	MISSION WH/HR/SQFT	0.037036	0.037036	0.037036	0.037036	0.037036	0.037036	0.037036	0.037036	0.037036	0.037036
42.1	Sentry Station	SUPPORT WH/HR/SQFT	3.059255	3.059255	3.059255	3.059255	3.059255	3.059255	3.059255	1.577775	1.577775	1.577775
42.1	Sentry Station	TOTAL WH/HR/SQFT	3.614810	3.614810	3.614810	3.614810	3.614810	3.614810	3.614810	1.718516	1.718516	1.718516
43.1	Detached Lavatory	LIGHTING WH/HR/SQFT	0.544789	0.544789	0.544789	0.544789	0.544789	0.544789	0.544789	0.622616	0.622616	0.622616
43.1	Detached Lavatory	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
43.1	Detached Lavatory	MISSION WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
43.1	Detached Lavatory	SUPPORT WH/HR/SQFT	0.925189	0.925189	0.925189	0.925189	0.925189	0.925189	0.925189	1.132992	1.132992	1.132992
43.1	Detached Lavatory	TOTAL WH/HR/SQFT	1.469978	1.469978	1.469978	1.469978	1.469978	1.469978	1.469978	1.755609	1.755609	1.755609
44.4	Wash Facility DEFAULT	LIGHTING WH/HR/WATTPUMPCAP	0	0	0	0	0	0	0	0	0	0
44.4	Wash Facility PUMP	MOTORS WH/HR/WATTPUMPCAP	0.010203	0.010203	0.010203	0.010203	0.010203	0.102031	0.252022	0.447764	0.447764	0.447764
44.4	Wash Facility CAPACITY	MISSION WH/HR/WATTPUMPCAP	0	0	0	0	0	0	0	0	0	0
44.4	Wash Facility 20KW	SUPPORT WH/HR/WATTPUMPCAP	0	0	0	0	0	0	0	0	0	0
44.4	Wash Facility	TOTAL WH/HR/WATTPUMPCAP	0.010203	0.010203	0.010203	0.010203	0.010203	0.102031	0.252022	0.447764	0.447764	0.447764
45	Rock Crusher	LIGHTING WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
45	Rock Crusher	MOTORS WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0.002080	0.014161	0.022711
45	Rock Crusher	MISSION WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
45	Rock Crusher	SUPPORT WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
45	Rock Crusher	TOTAL WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0.002080	0.014161	0.022711
46.1	Transmitter bldg	LIGHTING WH/HR/SQFT										
46.1	Transmitter bldg	MOTORS WH/HR/SQFT										
46.1	Transmitter bldg	MISSION WH/HR/SQFT										
46.1	Transmitter bldg	SUPPORT WH/HR/SQFT										
46.1	Transmitter bldg	TOTAL WH/HR/SQFT										
47.1	Installation Water Supply	LIGHTING WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
47.1	Installation Water Supply	MOTORS WH/HR/INSTLSQFT	0.115402	0.115472	0.109278	0.094243	[illegible]	0.002703	0.001265	[illegible]	0.003315	0.003014
47.1	Installation Water Supply	MISSION WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
47.1	Installation Water Supply	SUPPORT WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
47.1	Installation Water Supply	TOTAL WH/HR/INSTLSQFT	0.115402	0.115472	0.109278	0.094243	[illegible]	0.002703	0.001265	[illegible]	0.003315	0.003014
48.1	Exterior/Street Lighting	LIGHTING WH/HR/INSTLSQFT	0.096415	0.096415	0.096415	0.096415	0.050020	0.032130	0.016084	0.001071	0.001071	0.001071
48.1	Exterior/Street Lighting	MOTORS WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
48.1	Exterior/Street Lighting	MISSION WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
48.1	Exterior/Street Lighting	SUPPORT WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
48.1	Exterior/Street Lighting	TOTAL WH/HR/INSTLSQFT	0.096415	0.096415	0.096415	0.096415	0.050020	0.032130	0.016084	0.001071	0.001071	0.001071
49.1	Airfield	LIGHTING WH/HR/AIRSQFT	0.161929	0.174864	0.184709	0.171222	0.174448	0.195254	0.194105	[illegible]	[illegible]	[illegible]
49.1	Airfield	MOTORS WH/HR/AIRSQFT	0.004694	0.004467	0.004645	0.004737	0.005143	0.011263	0.005545	0.009014	0.010000	[illegible]
49.1	Airfield	MISSION WH/HR/AIRSQFT	2.761000	2.712521	2.714162	2.719404	2.711424	[illegible]	2.725425	3.042100	3.400474	[illegible]
49.1	Airfield	SUPPORT WH/HR/AIRSQFT	0.054562	0.039052	0.030567	0.031613	[illegible]	0.044802	0.062243	0.125020	0.156905	[illegible]
49.1	Airfield	TOTAL WH/HR/AIRSQFT	2.983090	2.936760	2.934170	2.927100	[illegible]	[illegible]	3.042369	3.424454	3.868596	[illegible]
50.1	Trng Ranges- heated targets	LIGHTING WH/HR/KWTARGETLOAD	0	0	0	0	0	0	0	0	0	0
50.1	Trng Ranges- heated targets	MOTORS WH/HR/KWTARGETLOAD	0	0	0	0	0	0	0	0	0	0
50.1	Trng Ranges- heated targets	MISSION WH/HR/KWTARGETLOAD	1464	1464	1464	1464	1464	1464	1464	1464	1464	1464
50.1	Trng Ranges- heated targets	SUPPORT WH/HR/KWTARGETLOAD	0	0	0	0	0	0	0	0	0	0
50.1	Trng Ranges- heated targets	TOTAL WH/HR/KWTARGETLOAD	1464	1464	1464	1464	1464	1464	1464	1464	1464	1464
51.2	Sewage Treatment Plant	LIGHTING WH/HR/INSTLSQFT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
51.2	Sewage Treatment Plant	MOTORS WH/HR/INSTLSQFT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.002502	[illegible]
51.2	Sewage Treatment Plant	MISSION WH/HR/INSTLSQFT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.000255	[illegible]
51.2	Sewage Treatment Plant	SUPPORT WH/HR/INSTLSQFT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.000001	[illegible]
51.2	Sewage Treatment Plant	TOTAL WH/HR/INSTLSQFT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.003576	[illegible]

PROFILE

No.	Name	Subprofiles & Total	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000
36	Library	MISSION WH/HR/SQFT	0.009437	0.200101	[illegible]	0.211169	0.161915	0.202712	0.270911	0.214442	0.176013	0.030033
36	Library	SUPPORT WH/HR/SQFT	0.101074	0.108131	0.111504	0.102698	0.110142	0.111053	0.111365	0.108058	0.105465	0.054396
36	Library	TOTAL WH/HR/SQFT	0.472261	1.034175	1.082100	1.022045	[illegible]	1.030447	1.069369	1.043067	1.003079	0.331407
37	Rec Center/ EM Club	LIGHTING WH/HR/SQFT	0.683610	0.576504	[illegible]	0.522163	0.548174	0.544530	0.570317	0.575905	0.571195	0.578376
37	Rec Center/ EM Club	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
37	Rec Center/ EM Club	MISSION WH/HR/SQFT	0.011250	0.020908	0.030451	0.052366	0.046422	0.046610	0.057806	0.058266	0.059695	0.060445
37	Rec Center/ EM Club	SUPPORT WH/HR/SQFT	0.075274	0.100375	0.108107	0.138959	0.139525	0.162379	0.141844	0.143234	0.142063	0.143849
37	Rec Center/ EM Club	TOTAL WH/HR/SQFT	0.770135	0.697788	0.606670	0.714490	0.734622	0.753520	0.769968	0.777405	0.772954	0.782671
38	Theater	LIGHTING WH/HR/SQFT	0.226982	0.269265	0.262719	0.270561	0.276242	0.230011	0.147747	0.192167	0.185412	0.326556
38	Theater	MOTORS WH/HR/SQFT	0.212819	0.232138	0.217265	0.227660	0.235005	0.237591	0.222394	0.197773	0.212968	0.437042
38	Theater	MISSION WH/HR/SQFT	0.000362	0.000496	0.000369	0.000388	0.000401	0.002641	0.075643	0.064724	0.056691	0.186991
38	Theater	SUPPORT WH/HR/SQFT	0.046519	0.057407	0.059602	0.056224	0.064742	0.043296	0.033448	0.039209	0.041784	0.077373
38	Theater	TOTAL WH/HR/SQFT	0.486683	0.559208	0.539957	0.554835	0.576393	0.522441	0.479234	0.493874	0.496856	1.027964
39	Class VI Store	LIGHTING WH/HR/SQFT	0.589049	0.589049	0.589049	0.589049	0.589049	0.589049	0.589049	0.589049	0.149587	0.069845
39	Class VI Store	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
39	Class VI Store	MISSION WH/HR/SQFT	1.662926	1.761813	1.645628	2.421081	1.640603	1.692889	1.527656	3.066978	1.699889	0.787756
39	Class VI Store	SUPPORT WH/HR/SQFT	0.721091	1.210459	1.391212	1.992194	0.898244	1.401028	1.199916	0.611312	0.132753	0.092594
39	Class VI Store	TOTAL WH/HR/SQFT	2.973068	3.561316	3.625891	5.002326	3.130897	3.682967	3.366622	4.267340	1.982229	0.950196
40.4	Misc Sheds/Garages/Detached Bldgs	LIGHTING WH/HR/SQFT	0.056609	0.056609	0.056609	0.056609	0.056609	0.033500	0.003928	0.003928	0.003928	0.003928
40.4	Misc Sheds/Garages/Detached Bldgs	MOTORS WH/HR/SQFT	0.005587	0.005587	0.005587	0.005587	0.005587	0.005587	0.004356	0.003574	0.003574	0.003574
40.4	Misc Sheds/Garages/Detached Bldgs	MISSION WH/HR/SQFT	0.035406	0.034479	0.035406	0.035406	0.035538	0.022695	0.008003	0.000264	0.000264	0.000264
40.4	Misc Sheds/Garages/Detached Bldgs	SUPPORT WH/HR/SQFT	0.175246	0.238474	0.241606	0.144073	0.143470	0.137665	0.106803	0.105391	0.070808	0.070808
40.4	Misc Sheds/Garages/Detached Bldgs	TOTAL WH/HR/SQFT	0.272929	0.335229	0.339289	0.242556	0.241265	0.199477	0.124091	0.113160	0.078576	0.078576
41	Post Office	LIGHTING WH/HR/SQFT	0.217230	0.228839	0.198429	0.219142	0.193356	0.211919	0.105939	0.107859	0.073982	0.062558
41	Post Office	MOTORS WH/HR/SQFT	0.012221	0.013681	0.012732	0.013075	0.010277	0.012198	0.009237	0.008273	0.005697	0.006951
41	Post Office	MISSION WH/HR/SQFT	0.258719	0.241735	0.220255	0.261557	0.231212	0.247845	0.204604	0.048639	0.027899	0.026048
41	Post Office	SUPPORT WH/HR/SQFT	0.130997	0.127888	0.125297	0.130386	0.128485	0.134756	0.101414	0.094107	0.079816	0.058555
41	Post Office	TOTAL WH/HR/SQFT	0.619168	0.612144	0.556715	0.624562	0.563332	0.606721	0.421276	0.258879	0.187396	0.154113
42.1	Sentry Station	LIGHTING WH/HR/SQFT	0.103703	0.103703	0.103703	0.103703	0.103703	0.103703	0.518517	0.518517	0.518517	0.518517
42.1	Sentry Station	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
42.1	Sentry Station	MISSION WH/HR/SQFT	0.037036	0.037036	0.037036	0.037036	0.037036	0.037036	0.037036	0.037036	0.037036	0.037036
42.1	Sentry Station	SUPPORT WH/HR/SQFT	1.577775	1.577775	1.577775	1.577775	1.577775	1.577775	3.059255	3.059255	3.059255	3.059255
42.1	Sentry Station	TOTAL WH/HR/SQFT	1.718516	1.718516	1.718516	1.718516	1.718516	1.718516	3.614810	3.614810	3.614810	3.614810
43.1	Detached Lavatory	LIGHTING WH/HR/SQFT	0.622616	0.622616	0.622616	0.622616	0.622616	0.622616	0.544789	0.544789	0.544789	0.544789
43.1	Detached Lavatory	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
43.1	Detached Lavatory	MISSION WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
43.1	Detached Lavatory	SUPPORT WH/HR/SQFT	1.132992	1.132992	1.132992	1.132992	1.132992	1.132992	0.925189	0.925189	0.925189	0.925189
43.1	Detached Lavatory	TOTAL WH/HR/SQFT	1.755609	1.755609	1.755609	1.755609	1.755609	1.755609	1.469978	1.469978	1.469978	1.469978
44.4	Wash Facility DEFAULT	LIGHTING WH/HR/WATTPUMPCAP	0	0	0	0	0	0	0	0	0	0
44.4	Wash Facility PUMP	MOTORS WH/HR/WATTPUMPCAP	0.447764	0.447764	0.447764	0.447764	0.514155	0.514155	0.499179	0.499179	0.361373	0.278542
44.4	Wash Facility CAPACITY	MISSION WH/HR/WATTPUMPCAP	0	0	0	0	0	0	0	0	0	0
44.4	Wash Facility 206KW	SUPPORT WH/HR/WATTPUMPCAP	0	0	0	0	0	0	0	0	0	0
44.4	Wash Facility	TOTAL WH/HR/WATTPUMPCAP	0.447764	0.447764	0.447764	0.447764	0.514155	0.514155	0.499179	0.499179	0.361373	0.278542
45	Rock Crusher	LIGHTING WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
45	Rock Crusher	MOTORS WH/HR/INSTLSQFT	0.022711	0.022711	0.022711	0.022711	0.018035	0.007080	0	0	0	0
45	Rock Crusher	MISSION WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
45	Rock Crusher	SUPPORT WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
45	Rock Crusher	TOTAL WH/HR/INSTLSQFT	0.022711	0.022711	0.022711	0.022711	0.018035	0.007080	0	0	0	0
46.1	Transmitter bldg	LIGHTING WH/HR/SQFT										
46.1	Transmitter bldg	MOTORS WH/HR/SQFT										
46.1	Transmitter bldg	MISSION WH/HR/SQFT										
46.1	Transmitter bldg	SUPPORT WH/HR/SQFT										
46.1	Transmitter bldg	TOTAL WH/HR/SQFT										
47.1	Installation Water Supply	LIGHTING WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
47.1	Installation Water Supply	MOTORS WH/HR/INSTLSQFT	0.000986	0.001242	0.019484	0.030937	0.046612	0.049397	0.046920	0.032481	0.014412	0.013161
47.1	Installation Water Supply	MISSION WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
47.1	Installation Water Supply	SUPPORT WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
47.1	Installation Water Supply	TOTAL WH/HR/INSTLSQFT	0.000986	0.001242	0.019484	0.030937	0.046612	0.049397	0.046920	0.032481	0.014412	0.013161
48.1	Exterior/Street Lighting	LIGHTING WH/HR/INSTLSQFT	0.001071	0.001071	0.001071	0.001071	0.001071	0.001071	0.021425	0.032138	0.074989	0.096415
48.1	Exterior/Street Lighting	MOTORS WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
48.1	Exterior/Street Lighting	MISSION WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
48.1	Exterior/Street Lighting	SUPPORT WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
48.1	Exterior/Street Lighting	TOTAL WH/HR/INSTLSQFT	0.001071	0.001071	0.001071	0.001071	0.001071	0.001071	0.021425	0.032138	0.074989	0.096415
49.1	Airfield	LIGHTING WH/HR/AIRSQFT	0.304243	0.318592	0.289760	0.316220	0.281930	0.379375	0.269869	0.262660	0.206485	0.171279
49.1	Airfield	MOTORS WH/HR/AIRSQFT	0.012219	0.013678	0.012737	0.013388	0.010268	0.012186	0.009239	0.008272	0.005698	0.006943
49.1	Airfield	MISSION WH/HR/AIRSQFT	3.643777	3.424795	3.465473	3.304892	3.411543	3.164310	3.302355	3.018887	3.065492	3.068945
49.1	Airfield	SUPPORT WH/HR/AIRSQFT	0.130978	0.127868	0.125344	0.130510	0.128364	0.134618	0.101433	0.094095	0.079825	0.058493
49.1	Airfield	TOTAL WH/HR/AIRSQFT	4.091219	3.884934	3.893315	3.765012	3.832106	3.691090	3.682897	3.383915	3.357501	3.305662
50.1	Trng Ranges- heated targets	LIGHTING WH/HR/KWTARGETLOAD	0	0	0	0	0	0	0	0	0	0
50.1	Trng Ranges- heated targets	MOTORS WH/HR/KWTARGETLOAD	0	0	0	0	0	0	0	0	0	0
50.1	Trng Ranges- heated targets	MISSION WH/HR/KWTARGETLOAD	1464	1464	1464	1464	1464	1464	1464	1464	1464	1464
50.1	Trng Ranges- heated targets	SUPPORT WH/HR/KWTARGETLOAD	0	0	0	0	0	0	0	0	0	0
50.1	Trng Ranges- heated targets	TOTAL WH/HR/KWTARGETLOAD	1464	1464	1464	1464	1464	1464	1464	1464	1464	1464
51.2	Sewage Treatment Plant	LIGHTING WH/HR/INSTLSQFT	0.000027	0.000027	0.000027	0.000027	0.000027	0.000013	0.000193	0.000387	0.000773	0.000773
51.2	Sewage Treatment Plant	MOTORS WH/HR/INSTLSQFT	0.007584	[illegible]	0.007560	0.007560	0.007560	0.007532	0.006319	0.007248	0.006490	0.006884
51.2	Sewage Treatment Plant	MISSION WH/HR/INSTLSQFT	0.000262	0.000262	0.000255	0.000255	0.000255	0.000262	0.000063	0.000075	0.000063	0.000050
51.2	Sewage Treatment Plant	SUPPORT WH/HR/INSTLSQFT	0.000801	0.001008	0.000801	0.000801	0.000801	0.000801	0.000762	0.000800	0.000227	0.000600
51.2	Sewage Treatment Plant	TOTAL WH/HR/INSTLSQFT	0.008676	0.010054	0.008645	0.008645	0.008645	0.008610	0.007338	0.008512	0.007555	0.008509

Facility No.	Name	Subprofiles & Total	2100	2200	2300	2400	SUM (WH/SF DY)	WKEND 100	200	300	400	500
[illegible]	Library	MISSION WH/HR/SQFT	0	0	0	0	1.2417[illegible]	0	0	0	0	0
[illegible]	Library	SUPPORT WH/HR/SQFT	0.052256	0.052014	0.05[illegible]	0.0[illegible]	1.2[illegible]	0.052244	0.050112	0.042420	0.049326	0.042970
[illegible]	Library	TOTAL WH/HR/SQFT	0.143454	0.136202	0.1[illegible]	0.1[illegible]520	11.[illegible]	0.130234	0.130442	0.137163	0.134923	0.137163
32	Rec Center/ EM Club	LIGHTING WH/HR/SQFT	0.602053	0.509792	0.164902	0.164144	9.8657288	0.209212	0.192202	0.200143	0.188768	0.190134
32	Rec Center/ EM Club	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
32	Rec Center/ EM Club	MISSION WH/HR/SQFT	0.046273	0.028285	0.004460	0.000187	0.5861685	0.000217	0.000217	0.000217	0.000216	0.000217
32	Rec Center/ EM Club	SUPPORT WH/HR/SQFT	0.122843	0.116815	0.046051	0.02[illegible]	1.8827542	0.009972	0.004594	0.009779	0.009077	0.009150
32	Rec Center/ EM Club	TOTAL WH/HR/SQFT	0.776169	0.654893	0.216214	0.1[illegible]308	12.334671	0.213401	0.207013	0.210140	0.198061	0.199502
38	Theater	LIGHTING WH/HR/SQFT	0.376660	0.377134	0.372204	0.367229	5.5882560	0.247127	0.263001	0.221824	0.195380	0.188477
38	Theater	MOTORS WH/HR/SQFT	0.504108	0.504741	0.490134	0.430152	5.6975072	0.444269	0.212077	0.138586	0.120785	0.116517
38	Theater	MISSION WH/HR/SQFT	0.206630	0.215951	0.177339	0.053907	1.0447776	0.000292	0.000372	0.000242	0.000211	0.000203
38	Theater	SUPPORT WH/HR/SQFT	0.086776	0.084410	0.063307	0.071394	1.0762258	0.052646	0.053996	0.019465	0.027181	0.016369
38	Theater	TOTAL WH/HR/SQFT	1.174183	1.182226	1.130066	0.922682	13.376366	0.744341	0.531047	0.380124	0.343558	0.321568
39	Class VI Store	LIGHTING WH/HR/SQFT	0.069845	0.069845	0.069845	0.069845	6.0560840	0.070730	0.070730	0.070730	0.070730	0.070730
39	Class VI Store	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
39	Class VI Store	MISSION WH/HR/SQFT	0.689620	0.755095	0.734455	0.687375	24.058920	0.683060	[illegible]	0.555225	0.586694	0.629718
39	Class VI Store	SUPPORT WH/HR/SQFT	0.092121	0.092121	0.092121	0.092121	11.005238	0.093288	0.093288	0.093288	0.093288	0.093288
39	Class VI Store	TOTAL WH/HR/SQFT	0.851587	0.917062	0.896422	0.849341	46.900248	0.847079	0.79[illegible]	0.719245	0.750714	0.793738
40.4	Misc Sheds/Garages/Detached Bldgs	LIGHTING WH/HR/SQFT	0.003928	0.003928	0.003928	0.003928	0.5628248	0.004936	0.004936	0.004936	0.004936	0.004936
40.4	Misc Sheds/Garages/Detached Bldgs	MOTORS WH/HR/SQFT	0.003574	0.003574	0.003574	0.003574	0.1050210	0.003926	0.003926	0.003926	0.003926	0.003926
40.4	Misc Sheds/Garages/Detached Bldgs	MISSION WH/HR/SQFT	0.000264	0.000264	0.000264	0.000264	0.2966783	0.000332	0.000332	0.000332	0.000332	0.000332
40.4	Misc Sheds/Garages/Detached Bldgs	SUPPORT WH/HR/SQFT	0.068001	0.102584	0.070808	0.069404	2.6693388	0.070474	0.106875	0.063420	0.065183	0.106875
40.4	Misc Sheds/Garages/Detached Bldgs	TOTAL WH/HR/SQFT	0.075769	0.110353	0.078576	0.077173	3.6338629	0.079669	0.116071	0.072615	0.074379	0.116071
41	Post Office	LIGHTING WH/HR/SQFT	0.063013	0.059517	0.057495	0.057400	2.9263666	0.056710	0.059516	0.059015	0.061312	0.060593
41	Post Office	MOTORS WH/HR/SQFT	0.005927	0.005927	0.004925	0.004625	0.1987520	0.005299	0.005230	0.005191	0.005435	0.005469
41	Post Office	MISSION WH/HR/SQFT	0.025264	0.024802	0.022[illegible]	0.022244	2.6923779	0.027139	0.027014	0.026750	0.027486	0.027454
41	Post Office	SUPPORT WH/HR/SQFT	0.046220	0.046381	0.047903	0.044004	2.0234256	0.036727	0.033294	0.033031	0.031007	0.031062
41	Post Office	TOTAL WH/HR/SQFT	0.140425	0.135030	0.132098	0.128274	7.8409023	0.125877	0.124053	0.123989	0.125242	0.124579
42.1	Sentry Station	LIGHTING WH/HR/SQFT	0.518517	0.518517	0.518517	0.518517	0.7111	0.518517	0.518517	0.518517	0.518517	0.518517
42.1	Sentry Station	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
42.1	Sentry Station	MISSION WH/HR/SQFT	0.037036	0.037036	0.037036	0.037036	0.8888877	0.037036	0.037036	0.037036	0.037036	0.037036
42.1	Sentry Station	SUPPORT WH/HR/SQFT	3.059255	3.059255	3.059255	3.059255	60.000812	3.059255	3.059255	3.059255	3.059255	3.059255
42.1	Sentry Station	TOTAL WH/HR/SQFT	3.614810	3.614810	3.614810	3.614810	69.6088	3.614810	3.614810	3.614810	3.614810	3.614810
43.1	Detached Lavatory	LIGHTING WH/HR/SQFT	0.544789	0.544789	0.544789	0.544789	13.725392	0.586428	0.586428	0.586428	0.586428	0.586426
43.1	Detached Lavatory	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
43.1	Detached Lavatory	MISSION WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
43.1	Detached Lavatory	SUPPORT WH/HR/SQFT	0.925189	0.925189	0.925189	0.925189	24.074775	0.995903	0.995903	0.995903	0.995903	0.995903
43.1	Detached Lavatory	TOTAL WH/HR/SQFT	1.469978	1.469978	1.469978	1.469978	37.850168	1.582331	1.582331	1.582331	1.582331	1.582331
44.4	Wash Facility DEFAULT	LIGHTING WH/HR/WHTTPUMPCAP	0	0	0	0	0	0	0	0	0	0
44.4	Wash Facility PUMP	MOTORS WH/HR/WHTTPUMPCAP	0.175711	0.025875	0.010283	0.010283	6.5044127	0.010283	0.010283	0.010283	0.010283	0.010283
44.4	Wash Facility CAPACITY	MISSION WH/HR/WHTTPUMPCAP	0	0	0	0	0	0	0	0	0	0
44.4	Wash Facility 206KW	SUPPORT WH/HR/WHTTPUMPCAP	0	0	0	0	0	0	0	0	0	0
44.4	Wash Facility	TOTAL WH/HR/WHTTPUMPCAP	0.175711	0.025875	0.010283	0.010283	6.5044127	0.010283	0.010283	0.010283	0.010283	0.010283
45	Rock Crusher	LIGHTING WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
45	Rock Crusher	MOTORS WH/HR/INSTLSQFT	0	0	0	0	0.1599187	0	0	0	0	0
45	Rock Crusher	MISSION WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
45	Rock Crusher	SUPPORT WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
45	Rock Crusher	TOTAL WH/HR/INSTLSQFT	0	0	0	0	0.1599187	0	0	0	0	0
46.1	Transmitter bldg	LIGHTING WH/HR/SQFT										
46.1	Transmitter bldg	MOTORS WH/HR/SQFT										
46.1	Transmitter bldg	MISSION WH/HR/SQFT										
46.1	Transmitter bldg	SUPPORT WH/HR/SQFT										
46.1	Transmitter bldg	TOTAL WH/HR/SQFT										
47.1	Installation Water Supply	LIGHTING WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
47.1	Installation Water Supply	MOTORS WH/HR/INSTLSQFT	0.044603	0.091754	0.096140	0.097562	1.0920753	0.120851	0.120902	0.115826	0.095805	0.046472
47.1	Installation Water Supply	MISSION WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
47.1	Installation Water Supply	SUPPORT WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
47.1	Installation Water Supply	TOTAL WH/HR/INSTLSQFT	0.044603	0.091754	0.096140	0.097562	1.0920753	0.120851	0.120902	0.115826	0.095805	0.046472
48.1	Exterior/Street Lighting	LIGHTING WH/HR/INSTLSQFT	0.096415	0.096415	0.096415	0.096415	1.1130656	0.096415	0.096415	0.096415	0.096415	0.058920
48.1	Exterior/Street Lighting	MOTORS WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
48.1	Exterior/Street Lighting	MISSION WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
48.1	Exterior/Street Lighting	SUPPORT WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
48.1	Exterior/Street Lighting	TOTAL WH/HR/INSTLSQFT	0.096415	0.096415	0.096415	0.096415	1.1130656	0.096415	0.096415	0.096415	0.096415	0.058920
49.1	Airfield	LIGHTING WH/HR/AIRSQFT	0.172432	0.184080	0.176810	0.162060	5.6310305	0.175533	0.170140	0.181819	0.169519	0.172452
49.1	Airfield	MOTORS WH/HR/AIRSQFT	0.005933	0.005326	0.004932	0.004629	0.1907165	0.005299	0.005241	0.005191	0.005432	0.005479
49.1	Airfield	MISSION WH/HR/AIRSQFT	3.092612	3.025524	2.906730	2.852064	73.860461	2.808405	2.830987	2.817809	2.876633	2.840882
49.1	Airfield	SUPPORT WH/HR/AIRSQFT	0.046261	0.046369	0.047969	0.044039	2.0232093	0.036725	0.033363	0.033029	0.030993	0.031119
49.1	Airfield	TOTAL WH/HR/AIRSQFT	3.317244	3.261309	3.136442	3.067794	81.722299	3.105963	3.039732	3.037849	3.082578	3.049934
50.1	Trng Ranges- heated targets	LIGHTING WH/HR/KWTARGETLOAD	0	0	0	0	0	0	0	0	0	0
50.1	Trng Ranges- heated targets	MOTORS WH/HR/KWTARGETLOAD	0	0	0	0	0	0	0	0	0	0
50.1	Trng Ranges- heated targets	MISSION WH/HR/KWTARGETLOAD	1464	1464	1464	1464	35136	1464	1464	1464	1464	1464
50.1	Trng Ranges- heated targets	SUPPORT WH/HR/KWTARGETLOAD	0	0	0	0	0	0	0	0	0	0
50.1	Trng Ranges- heated targets	TOTAL WH/HR/KWTARGETLOAD	1464	1464	1464	1464	35136	1464	1464	1464	1464	1464
51.2	Sewage Treatment Plant	LIGHTING WH/HR/INSTLSQFT	0.000773	0.000773	0.000773	0.000773	0.0111303	0.000773	0.000773	0.000773	0.000773	0.000773
51.2	Sewage Treatment Plant	MOTORS WH/HR/INSTLSQFT	0.006417	0.004800	0.006392	0.006392	0.1621242	0.006387	0.005860	0.005809	0.005954	0.005709
51.2	Sewage Treatment Plant	MISSION WH/HR/INSTLSQFT	0.000044	0.000041	0.000037	0.000037	0.0030060	0.000037	0.000037	0.000037	0.000037	0.000037
51.2	Sewage Treatment Plant	SUPPORT WH/HR/INSTLSQFT	0.000227	0.000000	0.000227	0.000227	0.0128362	0.000227	0.000724	0.000075	0.000113	0.000724
51.2	Sewage Treatment Plant	TOTAL WH/HR/INSTLSQFT	0.007462	0.005604	0.007431	0.007431	0.1942354	0.007426	0.007427	0.006696	0.006879	0.007245

PROFILE No.	Name		Subprofiles # Total	600	700	800	900	1000	1100	1200	1300	1400	1500
36	Library		MISSION WH/HR/SQFT	0	0	0.029586	0.000443	0.000478	0.000735	0.081552	0.101832	0.084574	0.088816
36	Library		SUPPORT WH/HR/SQFT	0.050111	0.052243	0.053407	0.051297	0.051474	0.098879	0.110173	0.112076	0.112172	0.110837
36	Library		TOTAL WH/HR/SQFT	0.137944	0.136485	0.174005	0.121123	0.110171	0.219548	0.511308	0.530611	0.513024	0.520548
37	Rec Center/ EM Club		LIGHTING WH/HR/SQFT	0.199862	0.215233	0.406635	0.709479	0.384454	0.254436	0.204648	0.254295	0.505861	0.528635
37	Rec Center/ EM Club		MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
37	Rec Center/ EM Club		MISSION WH/HR/SQFT	0.000217	0.000217	0.000217	0.000233	0.035779	0.054979	0.068028	0.067633	0.063011	0.053010
37	Rec Center/ EM Club		SUPPORT WH/HR/SQFT	0.009761	0.010727	0.032154	0.044134	0.096995	0.150921	0.171747	0.175539	0.143499	0.148888
37	Rec Center/ EM Club		TOTAL WH/HR/SQFT	0.209841	0.226177	0.439007	0.753846	0.519229	0.460337	0.444424	0.497467	0.712373	0.730534
38	Theater		LIGHTING WH/HR/SQFT	0.171225	0.153408	0.161384	0.180135	0.231221	0.263946	0.250850	0.226629	0.209918	0.223964
38	Theater		MOTORS WH/HR/SQFT	0.105852	0.094837	0.116485	0.142169	0.174056	0.219229	0.201321	0.162930	0.145864	0.135693
38	Theater		MISSION WH/HR/SQFT	0.000185	0.000165	0.000203	0.000248	0.000304	0.000383	0.000351	0.000284	0.000254	0.000237
38	Theater		SUPPORT WH/HR/SQFT	0.023820	0.024055	0.019697	0.028108	0.024564	0.055397	0.050936	0.045884	0.036904	0.038214
38	Theater		TOTAL WH/HR/SQFT	0.301084	0.272467	0.297770	0.350662	0.430147	0.538956	0.503460	0.435728	0.392942	0.398109
39	Class VI Store		LIGHTING WH/HR/SQFT	0.070730	0.070730	0.070730	0.070730	0.106704	0.215630	0.215630	0.215630	0.215630	0.215630
39	Class VI Store		MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
39	Class VI Store		MISSION WH/HR/SQFT	0.650712	0.681941	0.633525	0.579878	1.174523	1.452860	1.372775	1.292726	1.295179	1.373123
39	Class VI Store		SUPPORT WH/HR/SQFT	0.101485	0.104217	0.104217	0.104217	0.127755	0.165767	0.449244	0.453975	0.455229	0.164619
39	Class VI Store		TOTAL WH/HR/SQFT	0.822928	0.856889	0.808472	0.754826	1.408984	1.834258	2.037650	1.962333	1.966039	1.753373
40.4	Misc Sheds/Garages/Detached Bldgs		LIGHTING WH/HR/SQFT	0.004936	0.004936	0.004936	0.004936	0.004936	0.004936	0.004936	0.004936	0.004936	0.004936
40.4	Misc Sheds/Garages/Detached Bldgs		MOTORS WH/HR/SQFT	0.003926	0.003926	0.003926	0.003926	0.003926	0.003926	0.003926	0.003926	0.003926	0.003926
40.4	Misc Sheds/Garages/Detached Bldgs		MISSION WH/HR/SQFT	0.000332	0.000332	0.000332	0.000332	0.000332	0.000332	0.000332	0.000332	0.000332	0.000332
40.4	Misc Sheds/Garages/Detached Bldgs		SUPPORT WH/HR/SQFT	0.068710	0.070474	0.066947	0.106875	0.068710	0.066947	0.065183	0.068710	0.106875	0.068710
40.4	Misc Sheds/Garages/Detached Bldgs		TOTAL WH/HR/SQFT	0.077906	0.079669	0.076142	0.116071	0.077906	0.076142	0.074379	0.077906	0.116071	0.077906
41	Post Office		LIGHTING WH/HR/SQFT	0.055617	0.056352	0.048554	0.048452	0.051124	0.049562	0.053449	0.057928	0.059311	0.060382
41	Post Office		MOTORS WH/HR/SQFT	0.005235	0.005336	0.001531	0.002183	0.002418	0.002549	0.002675	0.002755	0.002831	0.002931
41	Post Office		MISSION WH/HR/SQFT	0.026252	0.026995	0.046833	0.043830	0.045295	0.045075	0.048827	0.051866	0.053965	0.053903
41	Post Office		SUPPORT WH/HR/SQFT	0.036873	0.040052	0.053494	0.063696	0.062776	0.066459	0.063292	0.059412	0.059303	0.057507
41	Post Office		TOTAL WH/HR/SQFT	0.123979	0.128736	0.150414	0.158171	0.161615	0.164447	0.168245	0.171962	0.175412	0.174724
42.1	Sentry Station		LIGHTING WH/HR/SQFT	0.518517	0.518517	0.103703	0.103703	0.103703	0.103703	0.103703	0.103703	0.103703	0.103703
42.1	Sentry Station		MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
42.1	Sentry Station		MISSION WH/HR/SQFT	0.037036	0.037036	0.037036	0.037036	0.037036	0.037036	0.037036	0.037036	0.037036	0.037036
42.1	Sentry Station		SUPPORT WH/HR/SQFT	3.059255	3.059255	1.577775	1.577775	1.577775	1.577775	1.577775	1.577775	1.577775	1.577775
42.1	Sentry Station		TOTAL WH/HR/SQFT	3.614810	3.614810	1.718516	1.718516	1.718516	1.718516	1.718516	1.718516	1.718516	1.718516
43.1	Detached Lavatory		LIGHTING WH/HR/SQFT	0.586428	0.586428	0.586428	0.586428	0.586428	0.586428	0.586428	0.586428	0.586428	0.586428
43.1	Detached Lavatory		MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
43.1	Detached Lavatory		MISSION WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
43.1	Detached Lavatory		SUPPORT WH/HR/SQFT	0.995903	0.995903	0.995903	0.995903	0.995903	0.995903	0.995903	0.995903	0.995903	0.995903
43.1	Detached Lavatory		TOTAL WH/HR/SQFT	1.582331	1.582331	1.582331	1.582331	1.582331	1.582331	1.582331	1.582331	1.582331	1.582331
44.4	Wash Facility	DEFAULT	LIGHTING WH/HR/WATTPUMPCAP	0	0	0	0	0	0	0	0	0	0
44.4	Wash Facility	PUMP	MOTORS WH/HR/WATTPUMPCAP	0.010283	0.102831	0.293517	0.293517	0.293517	0.293517	0.293517	0.293517	0.293517	0.293517
44.4	Wash Facility	CAPACITY	MISSION WH/HR/WATTPUMPCAP	0	0	0	0	0	0	0	0	0	0
44.4	Wash Facility	206KW	SUPPORT WH/HR/WATTPUMPCAP	0	0	0	0	0	0	0	0	0	0
44.4	Wash Facility		TOTAL WH/HR/WATTPUMPCAP	0.010283	0.102831	0.293517	0.293517	0.293517	0.293517	0.293517	0.293517	0.293517	0.293517
45	Rock Crusher		LIGHTING WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
45	Rock Crusher		MOTORS WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
45	Rock Crusher		MISSION WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
45	Rock Crusher		SUPPORT WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
45	Rock Crusher		TOTAL WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
46.1	Transmitter bldg		LIGHTING WH/HR/SQFT										
46.1	Transmitter bldg		MOTORS WH/HR/SQFT										
46.1	Transmitter bldg		MISSION WH/HR/SQFT										
46.1	Transmitter bldg		SUPPORT WH/HR/SQFT										
46.1	Transmitter bldg		TOTAL WH/HR/SQFT										
47.1	Installation Water Supply		LIGHTING WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
47.1	Installation Water Supply		MOTORS WH/HR/INSTLSQFT	0.004812	0.001859	0.001859	0.000645	0.000645	0.000947	0.003986	0.016944	0.032303	0.039985
47.1	Installation Water Supply		MISSION WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
47.1	Installation Water Supply		SUPPORT WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
47.1	Installation Water Supply		TOTAL WH/HR/INSTLSQFT	0.004812	0.001859	0.001859	0.000645	0.000645	0.000947	0.003986	0.016944	0.032303	0.039985
48.1	Exterior/Street Lighting		LIGHTING WH/HR/INSTLSQFT	0.032138	0.016069	0.001071	0.001071	0.001071	0.001071	0.001071	0.001071	0.001071	0.001071
48.1	Exterior/Street Lighting		MOTORS WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
48.1	Exterior/Street Lighting		MISSION WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
48.1	Exterior/Street Lighting		SUPPORT WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
48.1	Exterior/Street Lighting		TOTAL WH/HR/INSTLSQFT	0.032138	0.016069	0.001071	0.001071	0.001071	0.001071	0.001071	0.001071	0.001071	0.001071
49.1	Airfield		LIGHTING WH/HR/AIRSQFT	0.166032	0.156580	0.118816	0.147867	0.152032	0.137924	0.149887	0.149634	0.156603	0.149285
49.1	Airfield		MOTORS WH/HR/AIRSQFT	0.005241	0.005332	0.001532	0.002182	0.002421	0.002548	0.002678	0.002756	0.002836	0.002933
49.1	Airfield		MISSION WH/HR/AIRSQFT	2.821338	2.851215	2.925114	3.168726	3.189667	3.011087	3.234725	3.302983	3.308036	3.205067
49.1	Airfield		SUPPORT WH/HR/AIRSQFT	0.036918	0.040023	0.053516	0.063648	0.062853	0.066435	0.063363	0.059434	0.059416	0.057546
49.1	Airfield		TOTAL WH/HR/AIRSQFT	3.029531	3.053151	3.098979	3.382424	3.406986	3.217395	3.444653	3.514808	3.526893	3.414833
50.1	Trng Ranges- heated targets		LIGHTING WH/HR/KWTARGETLOAD	0	0	0	0	0	0	0	0	0	0
50.1	Trng Ranges- heated targets		MOTORS WH/HR/KWTARGETLOAD	0	0	0	0	0	0	0	0	0	0
50.1	Trng Ranges- heated targets		MISSION WH/HR/KWTARGETLOAD	1464	1464	1464	1464	1464	1464	1464	1464	1464	1464
50.1	Trng Ranges- heated targets		SUPPORT WH/HR/KWTARGETLOAD	0	0	0	0	0	0	0	0	0	0
50.1	Trng Ranges- heated targets		TOTAL WH/HR/KWTARGETLOAD	1464	1464	1464	1464	1464	1464	1464	1464	1464	1464
51.2	Sewage Treatment Plant		LIGHTING WH/HR/INSTLSQFT	0.000273	0.000002	0.000002	0.000002	0.000002	0.000002	0.000002	0.000002	0.000002	0.000002
51.2	Sewage Treatment Plant		MOTORS WH/HR/INSTLSQFT	0.006243	0.004920	0.003229	0.005706	0.003512	0.004606	0.004601	0.003507	0.005694	0.003507
51.2	Sewage Treatment Plant		MISSION WH/HR/INSTLSQFT	0.000037	0.000041	0.000043	0.000043	0.000041	0.000041	0.000040	0.000040	0.000040	0.000040
51.2	Sewage Treatment Plant		SUPPORT WH/HR/INSTLSQFT	0.000189	0.000227	0.000151	0.000800	0.000227	0.000514	0.000514	0.000227	0.000800	0.000227
51.2	Sewage Treatment Plant		TOTAL WH/HR/INSTLSQFT	0.007244	0.005584	0.003427	0.006553	0.003784	0.005165	0.005159	0.003778	0.006538	0.003778

PROFILE

No.	Name	Subprofiles & Total	1600	1700	1800	1900	2000	2100	2200	2300	2400	SUM (WH/SF/DY)
36	Library	MISSION WH/HR/SQFT	0.091481	0.110452	0.099412	[illegible]	[illegible]	0.001095	0.002011	0.002000	0.002080	[illegible]
36	Library	SUPPORT WH/HR/SQFT	0.110498	0.111910	0.109666	0.108004	[illegible]	0.052790	[illegible]	0.053022	0.051459	[illegible]
36	Library	TOTAL WH/HR/SQFT	0.625906	0.551256	0.544054	0.553376	[illegible]	0.134210	0.132730	0.138760	0.137197	6.552[illegible]
37	Rec Center/ EM Club	LIGHTING WH/HR/SQFT	0.520200	0.549940	0.590431	0.620822	0.624594	0.647971	0.584774	0.233202	0.201494	9.232447
37	Rec Center/ EM Club	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
37	Rec Center/ EM Club	MISSION WH/HR/SQFT	0.045148	0.056206	0.056856	0.052297	0.044249	0.030471	0.021592	0.008635	0.000217	0.661019
37	Rec Center/ EM Club	SUPPORT WH/HR/SQFT	0.174096	0.145256	0.146616	0.147346	0.140555	0.120160	0.009662	0.009253	0.011074	2.031366
37	Rec Center/ EM Club	TOTAL WH/HR/SQFT	0.747454	0.751403	0.793904	0.835466	0.815493	0.800605	0.695449	0.247091	0.212785	11.92465
38	Theater	LIGHTING WH/HR/SQFT	0.190248	0.145668	0.120723	0.119866	0.555211	0.380694	0.392017	0.395285	0.413451	5.710466
38	Theater	MOTORS WH/HR/SQFT	0.133141	0.118108	0.126005	0.161015	0.470665	0.515249	0.519653	0.523987	0.463671	5.563174
38	Theater	MISSION WH/HR/SQFT	0.000123	0.031228	0.041237	0.054430	0.226835	0.248217	0.241004	0.205366	0.131119	1.183510
38	Theater	SUPPORT WH/HR/SQFT	0.024262	0.019694	0.026371	0.031590	0.092382	0.098566	0.086906	0.092650	0.076957	1.066570
38	Theater	TOTAL WH/HR/SQFT	0.347775	0.314639	0.314338	0.366904	1.145295	1.250727	1.239581	1.217290	1.085198	13.52372
39	Class VI Store	LIGHTING WH/HR/SQFT	0.215630	0.215630	0.215630	0.106704	0.070730	0.070730	0.070730	0.070730	0.070730	2.928686
39	Class VI Store	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
39	Class VI Store	MISSION WH/HR/SQFT	1.438118	1.425141	1.462170	1.002941	0.690647	0.688824	0.629643	0.662964	0.646223	22.24317
39	Class VI Store	SUPPORT WH/HR/SQFT	0.517733	0.504512	0.479085	0.093288	0.093288	0.093288	0.093288	0.093288	0.093288	4.758257
39	Class VI Store	TOTAL WH/HR/SQFT	2.171482	2.145294	2.156807	1.202934	0.853666	0.852843	0.793663	0.826984	0.810243	29.93012
40.4	Misc Sheds/Garages/Detached Bldgs	LIGHTING WH/HR/SQFT	0.004936	0.004936	0.004936	0.004936	0.004936	0.004936	0.004936	0.004936	0.004936	0.1[illegible]
40.4	Misc Sheds/Garages/Detached Bldgs	MOTORS WH/HR/SQFT	0.003926	0.003926	0.003926	0.003926	0.003926	0.003926	0.003926	0.003926	0.003926	0.0[illegible]
40.4	Misc Sheds/Garages/Detached Bldgs	MISSION WH/HR/SQFT	0.000332	0.000332	0.000332	0.000332	0.000332	0.000332	0.000332	0.000332	0.000332	0.0[illegible]
40.4	Misc Sheds/Garages/Detached Bldgs	SUPPORT WH/HR/SQFT	0.065183	0.066947	0.105112	0.068710	0.066947	0.065183	0.106875	0.065183	0.068710	1.849831
40.4	Misc Sheds/Garages/Detached Bldgs	TOTAL WH/HR/SQFT	0.074379	0.076142	0.114307	0.077906	0.076142	0.074379	0.116071	0.074379	0.077906	2.070525
41	Post Office	LIGHTING WH/HR/SQFT	0.056555	0.057337	0.054798	0.055116	0.055238	0.057782	0.052010	0.050978	0.055177	1.337479
41	Post Office	MOTORS WH/HR/SQFT	0.002564	0.003811	0.006049	0.005754	0.005543	0.005360	0.005103	0.004849	0.005125	0.101237
41	Post Office	MISSION WH/HR/SQFT	0.049360	0.033396	0.029417	0.026139	0.027646	0.028096	0.027564	0.025677	0.026926	0.855932
41	Post Office	SUPPORT WH/HR/SQFT	0.055523	0.050217	0.052100	0.044977	0.045351	0.040119	0.039004	0.043826	0.040041	1.139152
41	Post Office	TOTAL WH/HR/SQFT	0.164011	0.145362	0.142365	0.133988	0.133978	0.131358	0.128683	0.125330	0.127271	3.433801
42.1	Sentry Station	LIGHTING WH/HR/SQFT	0.103703	0.518517	0.518517	0.518517	0.518517	0.518517	0.518517	0.518517	0.518517	8.7111
42.1	Sentry Station	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
42.1	Sentry Station	MISSION WH/HR/SQFT	0.037036	0.037036	0.037036	0.037036	0.037036	0.037036	0.037036	0.037036	0.037036	0.888887
42.1	Sentry Station	SUPPORT WH/HR/SQFT	1.577775	3.059255	3.059255	3.059255	3.059255	3.059255	3.059255	3.059255	3.059255	60.08881
42.1	Sentry Station	TOTAL WH/HR/SQFT	1.718516	3.614810	3.614810	3.614810	3.614810	3.614810	3.614810	3.614810	3.614810	69.6886
43.1	Detached Lavatory	LIGHTING WH/HR/SQFT	0.586428	0.586428	0.586428	0.586428	0.586428	0.586428	0.586428	0.586428	0.586428	14.07429
43.1	Detached Lavatory	MOTORS WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
43.1	Detached Lavatory	MISSION WH/HR/SQFT	0	0	0	0	0	0	0	0	0	0
43.1	Detached Lavatory	SUPPORT WH/HR/SQFT	0.995903	0.995903	0.995903	0.995903	0.995903	0.995903	0.995903	0.995903	0.995903	23.90167
43.1	Detached Lavatory	TOTAL WH/HR/SQFT	1.582331	1.582331	1.582331	1.582331	1.582331	1.582331	1.582331	1.582331	1.582331	37.97536
44.4	Wash Facility DEFAULT	LIGHTING WH/HR/WATTPUMPCAP	0	0	0	0	0	0	0	0	0	0
44.4	Wash Facility PUMP	MOTORS WH/HR/WATTPUMPCAP	0.329957	0.314982	0.278542	0.190686	0.102631	0.010283	0.010283	0.010283	0.010283	3.770804
44.4	Wash Facility CAPACITY	MISSION WH/HR/WATTPUMPCAP	0	0	0	0	0	0	0	0	0	0
44.4	Wash Facility 206KW	SUPPORT WH/HR/WATTPUMPCAP	0	0	0	0	0	0	0	0	0	0
44.4	Wash Facility	TOTAL WH/HR/WATTPUMPCAP	0.329957	0.314982	0.278542	0.190686	0.102631	0.010283	0.010283	0.010283	0.010283	3.770804
45	Rock Crusher	LIGHTING WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
45	Rock Crusher	MOTORS WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
45	Rock Crusher	MISSION WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
45	Rock Crusher	SUPPORT WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
45	Rock Crusher	TOTAL WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
46.1	Transmitter bldg	LIGHTING WH/HR/SQFT										
46.1	Transmitter bldg	MOTORS WH/HR/SQFT										
46.1	Transmitter bldg	MISSION WH/HR/SQFT										
46.1	Transmitter bldg	SUPPORT WH/HR/SQFT										
46.1	Transmitter bldg	TOTAL WH/HR/SQFT										
47.1	Installation Water Supply	LIGHTING WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
47.1	Installation Water Supply	MOTORS WH/HR/INSTLSQFT	0.041959	0.038626	0.019097	0.008777	0.007631	0.048266	0.105515	0.109176	0.109176	1.092075
47.1	Installation Water Supply	MISSION WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
47.1	Installation Water Supply	SUPPORT WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
47.1	Installation Water Supply	TOTAL WH/HR/INSTLSQFT	0.041959	0.038626	0.019097	0.008777	0.007631	0.048266	0.105515	0.109176	0.109176	1.092075
48.1	Exterior/Street Lighting	LIGHTING WH/HR/INSTLSQFT	0.001071	0.021425	0.032138	0.074989	0.096415	0.096415	0.096415	0.096415	0.096415	1.113065
48.1	Exterior/Street Lighting	MOTORS WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
48.1	Exterior/Street Lighting	MISSION WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
48.1	Exterior/Street Lighting	SUPPORT WH/HR/INSTLSQFT	0	0	0	0	0	0	0	0	0	0
48.1	Exterior/Street Lighting	TOTAL WH/HR/INSTLSQFT	0.001071	0.021425	0.032138	0.074989	0.096415	0.096415	0.096415	0.096415	0.096415	1.113065
49.1	Airfield	LIGHTING WH/HR/AIRSQFT	0.224966	0.221127	0.210151	0.180904	0.164131	0.165254	0.162123	0.169465	0.164828	4.038604
49.1	Airfield	MOTORS WH/HR/AIRSQFT	0.002564	0.003864	0.006047	0.005752	0.005542	0.005369	0.005106	0.004847	0.005126	0.101270
49.1	Airfield	MISSION WH/HR/AIRSQFT	3.057785	2.996284	3.117509	3.265455	3.142218	3.066695	3.063411	2.997382	2.885447	72.86487
49.1	Airfield	SUPPORT WH/HR/AIRSQFT	0.055517	0.050128	0.052089	0.044963	0.045342	0.040185	0.039027	0.043816	0.040046	1.139516
49.1	Airfield	TOTAL WH/HR/AIRSQFT	3.340833	3.271305	3.385798	3.505156	3.357234	3.277506	3.269669	3.215512	3.095448	78.14426
50.1	Trng Ranges- heated targets	LIGHTING WH/HR/KWTARGETLOAD	0	0	0	0	0	0	0	0	0	0
50.1	Trng Ranges- heated targets	MOTORS WH/HR/KWTARGETLOAD	0	0	0	0	0	0	0	0	0	0
50.1	Trng Ranges- heated targets	MISSION WH/HR/KWTARGETLOAD	1464	1464	1464	1464	1464	1464	1464	1464	1464	35136
50.1	Trng Ranges- heated targets	SUPPORT WH/HR/KWTARGETLOAD	0	0	0	0	0	0	0	0	0	0
50.1	Trng Ranges- heated targets	TOTAL WH/HR/KWTARGETLOAD	1464	1464	1464	1464	1464	1464	1464	1464	1464	35136
51.2	Sewage Treatment Plant	LIGHTING WH/HR/INSTLSQFT	0.000002	0.000143	0.000182	0.000223	0.000274	0.000223	0.000223	0.000223	0.000273	0.010279
51.2	Sewage Treatment Plant	MOTORS WH/HR/INSTLSQFT	0.004606	0.004200	0.007113	0.006404	0.007484	0.006400	0.007227	0.006433	0.007479	0.136693
51.2	Sewage Treatment Plant	MISSION WH/HR/INSTLSQFT	0.000041	0.000041	0.000041	0.000041	0.000040	0.000040	0.000039	0.000037	0.000037	0.000962
51.2	Sewage Treatment Plant	SUPPORT WH/HR/INSTLSQFT	0.000514	0.000222	0.000000	0.000222	0.000514	0.000227	0.000224	0.000239	0.000514	0.009742
51.2	Sewage Treatment Plant	TOTAL WH/HR/INSTLSQFT	0.005165	0.004605	0.008342	0.007946	0.008010	0.007442	0.008815	0.007484	0.008805	0.153677

APPENDIX D:

LIGHTING SURVEY QUESTIONS AND RESULTS

The questions listed below were answered by the auditor during the lighting field audit. Responses to the 13 questions are tallied on the next page.

Question No.	
1	What is the quality of wall reflectivity?
2	What is the quality of ceiling reflectivity?
3	What is the quality of floor reflectivity?
	(g = good; f = fair; p = poor)
4	Will fixture spacing permit fixture deletions without excessive dark spots?
5	Would (remotely controlled) unscheduled shutting off lighting be tolerable?
6	Would (remotely controlled) unscheduled dimming of lights be tolerable?
7	Is there a task lighting potential?
8	Is there a daylighting potential?
9	Is there a potential for time(r) control?
10	Is there a potential for task level switching?
11	Is there a potential for task area switching?
12	Could more accessible light switches possibly contribute to increased turning lights "off"?
13	Is there a potential for using occupancy sensors?
	(y = yes; n = no)

COM-UNTY	BLDG NO.	RM TYPE	ROOM DESCRIPTN	AUDIT WATTS	FLOOR AREA LNG ft	FLOOR AREA WID ft	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13
Hoh	49	a	libr/of	1308	32	36	g	g	f	n	y	y	n		y	n	y	n	y
Hoh	1A	a	of-4p	576	17	19	f	f	p	t	n	y	y	n		y	y	y	y
Hoh	12	a	of-5p	384	13	21	g	g	f	n	n	y	y		y	n	y	n	y
Hoh	745	a	of	96	12	12	f	g	g	n	n	y	y	n	n	n	n	n	y
Hoh	41	a	office	360	9	11	p	p	p	y	n	n	y	n	y	y	y	n	y
Hoh	703	a	of-files	432	28	36	g	g	p	y	n	y	y	N	n	y	y	y	y
Hoh	9	a	of-2p	96	11	12	f	g	p	n	n	y	y	n	y	y	n	y	y
Hoh	270	a	of	870	22	26	g	g	p	n	n	y	y	n	n	y	y	n	n
Hoh	739	a	of-observ	288	10	15	g	g	p		n	y	y	y	n	y	n	n	n
Hoh	17	a	of	180	14	14	f	g	g	n	n	y	y	y	y	y	y		y
Graf	441	a	of/cashier	384	10	20	p			y	n	y	y	n	y		n		y
Graf	531	a	of-3p	384	17	18	g			n	n	y	y	n	n	y	y	n	y
Graf	141A	a	of	252	16	16	f	g	p	n	n	y	y	n	n	n	y	n	y
Graf	602	a	of-4p	576	13	22							y	n	y	y	n	y	y
Graf	2026	a	of	121	9	10	p	g	f	n			y	n	n	n	n	n	y
Graf	531	a	lect. of	864	13	29	g	g	g	y	n	y	y	y	n	y	n	n	y
Graf	1030	a	of	192	9	10	f	p	p	n	y	y	y	n	n	y	n	n	y
Graf	2025	a	of-product	540	12	25	f	f	p	n			y	n	n	n	y	n	y
Graf	500	a	of	96	9	14	f	g	p	n		y	y	y	y	y	n	n	y
Graf	129	a	of/exam	312	18	22				n	n	n	n	n	n	n	n	n	y
Graf	129	a	Dr. of	576	9	12	g	g	f	y	n	n	y	n	n	y	n	n	y
Hoh	745	b	hall	336	6	96				n	y	y	n	n	y	n	y	y	y
Hoh	20	b	hall	900	6	76	g	g	g		y	y	n	n	y	y	n	y	y
Hoh	5	b	hall	600	7	60	g	g	p	y	y	y	n	n	y	n	n	n	y
Hoh	17	b	hall	720	6	76	g	g	g	n	y	y	n	n	y	y	n	n	y
Hoh	1A	b	hall3	680	8	142	f	g	p	n	y	y	n	n	y	n	n	n	y
Hoh	42	b	wait/hall	1620	21	25	g	g	f	y	y	y	y	n	y		n	n	y
Graf	547	b	hall/exerc	960	6	100	g	g	g	m	y	y	n	n	y	n	n	y	y
Graf	531	b	hall	126	6	83	g	g	g	n	y	y	n	y	y	n	n	y	y
Graf	500	b	hall 1fl	144	7	63	f	g	g	n		y	n	y	y	n	y	n	y
Hoh	174	c	sink rm	96	17	20	g	g	g	n	n	y	n	n	n	n	n	n	y
Hoh	174	c	shower rm	48	11	17	g	g	g	n	n	y	n	n	n	n	n	n	y
Hoh	3	c	W-WC	296	10	16	f	f	p	y	n	y	n	n	n	y	y	y	y
Hoh	703	c	W-WC	60	6	35	g	g	p	n	n		n	n	n	n	n	n	y
Graf	547	c	W - locker	636	14	28	p	g	g	n	n	y	n	n	n	n		y	y
Graf	500	c	WC -m/f	144	13	19	g	g	g	n		y	n	n	y		n	y	y
Hoh	36	d	bay area 1	960	30	46	g	g	p	n	n	y	y	n	y	y	y		y
Hoh	88	d	gymnasium	4368	75	88	f	f	f	y	n	y	n	n	y	y	y	y	y
Hoh	5	d	classroom	2160	27	28	f	g	p	n	n		n		y	y	y	n	n
Hoh	270	d	briefing r	264	38	54	g	g	g	n	n		n	n	n	y	y	y	y
Hoh	50	d	game rm1	960	36	48	p	g	f	n	y	y	n	n	y	y	y		y
Hoh	H15	d	retail sto	2112	6	51	f	g	p	n	n	y	n	n	y	n	n	n	n
Hoh	49	d	libr rm2	1212	32	37	g	g	p	n			n	n	y		y	y	y
Hoh	2	d	church	1920	37	49	g	g	p	y	y	y	n	n					y
Hoh	17	d	dorm	180	11	14	g	g	g	n	y	y	n	y	n	y	y	n	n
Hoh	41	d	lobby/of	2250	14	33	p	g	p	y	n	n	n	n	y	n	n	n	n
Hoh	1B	d	grocery	1920	32	88	p	g	p		n	y	n	n	y	n	n	n	n
Hoh	88	d	hnd ball#2	2304	20	40	g	g	f		n	y	n	n	y	n	n	y	y
Hoh	1A	d	conference	840	20	38	f	g	p	y	n	y	n	n	n	y	y	n	y
Hoh	12	d	warehouse	2880	41	119	g	f	p		n	y	n	n	y	y	y	y	y
Hoh	14	d	b. lanes	2352	41	90	p	f	f	n	n	y	y	n	y	n	y		y
Hoh	9	d	veh stat.	2784	64	84	f	f	b	n	n	y	n	n	y	y	y		y
Hoh	18	d	ceramic	360	18	20	g	g	g	n	n	y	n	n	y	y	y	n	y
Hoh	169	d	retail	2490	20	21	p	g	p	n	n	y	n	n	y	n	n	n	n
Hoh	10	d	D4 wareh	2496	58	78	g	g	p	n	n	y	n	n	y	y	y	n	y
Hoh	88	d	L - locker	384	15	25	g	g	g	n	n	y	n	n	y	n	n	y	y
Hoh	14	d	b. lanes	2240	41	90	p	f	f	n	n	y	y	n	y	n	y		y
Hoh	169	d	stock rm	384	15	52	p	f	p	n	y	y	n	n	y	n	y	n	y
Hoh	2045	d	hanger	2700	75	106	f	f	f	n	n	y	y	n	n	n	n	n	n
Hoh	10	d	activeware	2592	58	79	g	g	p	n	n	y	n	n	y	y	y	n	y
Hoh	386	d	class rm	576	28	32	g	g	f	n	n	y	n	n	n	n	n	n	n
Hoh	40	d	multi purp	5850	31	101	g	g	f	y	y	y	n	y	n	y	y	y	y
Hoh	42	d	classroom	900	8	13	g	g	f	y	n	y	n	n			n	n	y
Hoh	3c	d	eating	2958	38	58	p	g	p	n	y	y	n	n	y	y	n	n	n
Hoh	18	d	woodshop	2112	25	65	g	g	g	y	n	n	n	n	y	y	y	y	y
Graf	445	d	dining	3440	48	51	g	g	p	y	n	y	n	?	y	y	y	n	y
Graf	212	d		186	9	12	g	g	p	n	y	y	n	n	n	n	n	n	n
Graf	2025	d	hanger	3996	46	49	p	f	p	n	n	y	y	n	n	y	y	y	y
Graf	141	d	? furnish.	4238	16	56	p	g	f	n	n	y	n	n					
Graf	1008	d	retail	3054	22	57	p	g	p		n	y	n	n	y	n	n	n	n
Graf	2442	d	laundry	3360	32	35	f	f	g	y	y		n	n	y	n	y		y
Graf	2026	d	hanger	2152	32	32	p	p	f	n	n		y	n	n	n	n	n	n
Graf	602	d	conference	1440	16	21	f	g	g	y	y	y	n	y	y	y	n	n	y
Graf	141A	d	retail	1632	10	48	p	f	f	n	n	y	n	n	n	n	n	n	n
Graf	319	d	warehouse	7002	70	91	p	p	f	n	n	y	n	n	y	n	y	n	y

APPENDIX E:

ARMY SAVES ENERGY BY IDENTIFYING AND REPLACING OVERSIZED MOTORS*

Abstract

A quick, easy-to-use method for identifying oversized polyphase induction motors is described. Results of a field study on the success of the method are given. Replacement of 68 electric motors in HVAC systems at an Army installation has resulted in a 17 percent decrease in electric power demand form the motors while they supply the same load.

Electric motors use a significant amount of electrical power. Some heating, ventilating, and air-conditioning (HVAC) systems contain a.c. motors which have been oversized for various reasons--from overcautious design to a forgotten temporary replacement unit. These motors are expensive both in terms of power demand and operating costs. And, the more oversized units in service, the higher the price for annual power supply.

The energy loss is easy to appreciate when an oversized motor operating at, say, 40 to 50 percent is compared with the integral horsepower motors manufactured today; properly sized motors can be 75 to 95 percent efficient, depending mainly on design and size.

The U.S. Army Constructing Engineering Research Laboratory (USACERL) examined motor sizing on the HVAC system at one Army installation. the twofold objective was to: (1) determine if oversized units were online and, if so, (2) project how much the energy demand would decline if these motors were replaced.

The first challenge for USACERL was to find a way to assess a motor's size as it operates in the system. This evaluation would identify motors oversized motors were found, the correct size of replacement units had to be determined.

Assessing Online Motor Efficiency

Institute of Electrical and Electronic Engineers (IEEE) Standard 112, "Test Procedure for Polyphase Induction Motors and Generators," specifies several methods for determining motor efficiency. However, these test methods are intended to be performed in a laboratory setting. They are much too involved, if not impossible, for field implementation.

USACERL has successfully used digital phototachometers with resolutions of ±1 rpm to approximate motor efficiency in a matter of minutes. The procedure for measuring motor speed is simple: the researcher sticks a reflective tape on the motor shaft, places the motor in operation, points the phototachometer at the taped area, and reads the motor's rotational speed. The speed and motor nameplate data are then inserted into mathematical formulas to approximate the online motor load and efficiency.

USACERL developed the formulas for HVAC systems that use primarily NEMA Design B motors. Specifically, the Design B is a relatively low starting torque polyphase induction motor.

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*Authored by David Underwood and Larry Windingland, U.S. Army Construction Engineering Research Laboratory, Champaign, IL. A related article entitled "Save Energy by Replacing Oversize Electric Motors" appeared in *Power Engineering's* April 1987 issue.

In developing an equation for motor efficiency, the first step is to determine the fractional load (FL), defined as the ratio of delivered horsepower to rated horsepower, and its relationship to motor speed. This relationship, which is nearly linear (except during start-up), involves three parameters: synchronous rpm value (RPM_{sync}), operating speed rpm (RPM_{meas}), and the nameplate rpm (RPM_{np}).

RPM_{sync} is a function of line frequency and motor design (number of poles); RPM_{meas} is the operating speed of the motor which should be measured when the motor is under maximum system load; and RPM_{np} is stamped on the motor's nameplate and indicates the speed at which it operates while delivering its rated horsepower (HP_{np}). By definition, when $RPM_{meas} = RPM_{sync}$, FL = 0 percent and when $RPM_{meas} = RPM_{np}$, FL = 100 percent. Assuming linearity between these two points, FL can be computer at any operating point using Equation 1:

$$FL(\%) = 100(RPM_{sync} - RPM_{meas})/(RPM_{sync} - RPM_{np}) \quad \text{[Eq 1]}$$

$$= BHP/HP_{np}$$

As an example, consider a 20-HP motor with a nameplate rpm of 1740, synchronous speed of 1800 rpm, and operating speed measured at 1780 rpm:

$$FL(\%) = 100(1800)/(1800 - 1740)$$

$$= 33\%$$

The replacement motor selected should be the smallest size that will not incur a load greater than its rating (FL $\leq$ 100 percent). Most motors are designed to withstand loads equal to 115 percent of their nameplate horsepower as a built-in margin of error.

Also important in choosing a replacement motor is to confirm the brake horsepower (BHP). All motors in the USACERL study used adjustable belt drives to spin centrifugal fans. This type of setup permits a simple adjustment to ensure that the replacement motors delivers the same BHP as the original. Without this adjustment, the more efficiently running motor could actually consume more power than the original if the new motor is delivering a greater BHP. In case of centrifugal fans, this condition would result in a greater airflow.

Assuming the replacement motor can be adjusted after installation to insure equivalent BHP, the relationship in Equation 2 approximates the replacement motor size:

$$BHP = (FL_r)\ (HPN_r) = (FL_o)(HPN_o) \quad \text{[Eq 2]}$$

$$HPN_r = (FL_o\%)(HPN_o)/100\%$$

$$= (33\%)(20\ HP)/100\% = 6.6\ HP$$

where HPN_r is the nameplate horsepower of the replacement motor (The subscript r indicates "replacement" and o signifies "original".)

Continuing with the example, 7.5-HP motor is the nearest size available that will not be overloaded. Rearranging Equation 2 and substituting the known variables yields:

$$FL_r(\%) = (33\%)(20\ HP)/7.5\ HP = 88\%$$

Once the fractional loads have been determined, the efficiencies can be estimated from performance curves. Equation 3 approximates the performance curve of a typical NEMA Design B motor:

$$E_{motor} = 16.1 + 170(FL) - 100(FL)^2 \qquad \text{[Eq 3]}$$

which gives the percentage motor efficiency at corresponding fractional load. In the example, FL_o = 33 percent; FL_r = 88 percent; E_o = 61 percent; and E_r = 88 percent, where E_o and E_r refer to efficiency of the old replacement motors, respectively, as computed in Equation 3.

Savings

From the sample calculations, the change in horsepower demand can be translated into savings accrued:

$$\text{Change in HP demand} = (HP_{delivered}/E_o) - (HP_{delivered}/E_r) \qquad \text{[Eq 4]}$$

$$= BHP \times \frac{1}{E_o} - \frac{1}{E_o}$$

$$= FL_o \times HPN_o[(1/E_o) - (1/E_r)]$$

$$\text{Change in kW demand} = 0.746 \times FL_o \times HP_{npo}\,[(1/E_o) - (1/E_r)]$$

At \$0.06/kWh and 8760 hr of operation per year:

$$\text{Savings} = \$0.06/\text{kWh} \times 8760\ \text{hr/yr} \times 0.746\ \text{kW/HP} \times 0.33\% \times$$

$$20\ \text{HP}\ [(1/0.61\% - 1/0.88\%)]$$

$$= \$1294/\text{year}$$

Assuming a 7.5-HP motor costs around \$300 and installation is about \$200 for a total replacement cost of \$500, a simple payback of less than 5 months can be realized.

Results and Discussions

Using the methods and formulas described, USACERL found that the HVAC system studied could benefit through replacement of oversized motors. Testing revealed that 104 (or 52 percent) of the 201 motors surveyed were oversized, with some having operating efficiencies as low as 50 percent. The rpm measurements confirmed that 78 of the 104 should indeed be replaced. However, 10 of those motors could not be replaced for various reasons.

Replacement of 68 motors resulted in a 17 percent decrease in electrical power demand. These savings yielded a payback of 5 years or less. The results are conclusive: oversized motor replacement can reduce power demand and boost the power factor for large HVAC systems.

Application to Other Motors

The formulas given here were developed specifically for the NEMA Design B motor. However, similar equations for other designs of nonsynchronous motors could be developed easily using these same principles. The most significant difference would be in the load-slip relationship which also affects efficiency. Equation 3 would therefore have constants of values different than those obtained from the curve fit of a typical NEMA Design B performance curve.

Point of Contact

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